Final Program and Abstracts

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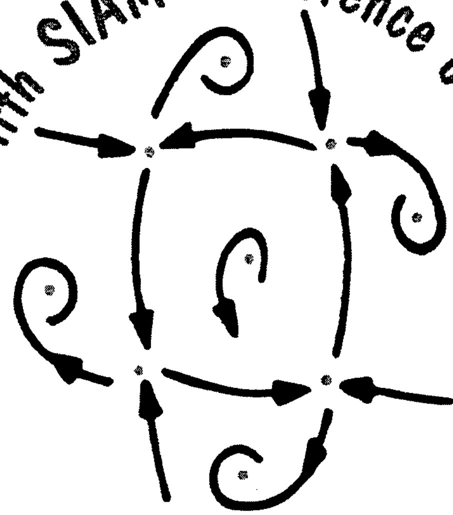
Fifth SIAM Conference on



APPLICATIONS of DYNAMICAL SYSTEMS

May 23-27, 1999

Snowbird Ski and Summer Resort • Snowbird, Utah

Sponsored by SIAM Activity Group on Dynamical Systems

Conference Themes

The themes of the 1999 conference include, but are not limited to

Principal Themes:
- Recent advances in the theory of nonlinear PDEs
- Orbital dynamics and space mission design
- Industrial mathematics: computational issues and modeling
- Molecular dynamics and DNA coding
- Ergodic theory and nonequilibrium statistical mechanics
- Data analysis, prediction and control

Applications in:
- Granular media
- Polymer flows
- Solid mechanics
- Oceanography and geophysical flows
- Biochemistry and biomolecular models

www.siam.org/meetings/ds99/

SIAM Society for Industrial and Applied Mathematics

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Hotel Floor Map .... Back cover

Organizing Committee

Emily Stone, Chair
Department of Mathematics and Statistics, Utah State University

Dieter Armbruster, Co-chair
Department of Mathematics, Arizona State University

Peter Bates
Department of Mathematics, Brigham Young University

Shui Nee Chow
School of Mathematics, Georgia Institute of Technology

Raymond Goldstein
Department of Physics, University of Arizona

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School of Mathematics, Georgia Institute of Technology

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Control and Dynamical Systems, California Institute of Technology

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School of Mathematics, Georgia Institute of Technology

Mary Silber
Engineering Sciences and Applied Mathematics, Northwestern University

Steven H. Strogatz
Theoretical and Applied Mechanics, Cornell University

James A. Yorke
Institute of Physical Science and Technology, University of Maryland, College Park

Get-Togethers

Welcoming Reception
6:00 PM–8:00 PM, Saturday, May 22
Ballrooms I, II, and III

SIAG/DS Business Meeting
5:00 PM–6:00 PM, Monday, May 24
Ballroom I

Poster Session and Dessert Reception
8:00 PM–10:000 PM, Wednesday, May 26
Ballrooms I, II, and III

About the Conference

The application of dynamical systems theory to areas outside of mathematics has proven to be an exciting and fruitful endeavor. The applications are highly diverse and interdisciplinary, ranging over such fields as Physics, Biology and Ecology, Engineering, Finance, Industrial Mathematics, Chemistry, Biochemistry and Genetics.

This conference strives to achieve an exciting mixture of applications and mathematics. The goals of the conference are a cross-fertilization between the different fields of the applications, and increased communication between the mathematicians who build the theory, and the scientists who use it.

Funding Agency

SIAM and the Conference Organizing Committee wish to extend their thanks and appreciation to the Office of Naval Research for its support of this conference.

Program-At-A-Glance

Quick Guide to
Dynamical Systems
Conference 1999

OPEN HERE

Program-At-A-Glance

Saturday, May 22 and Sunday, May 23

6:00 PM-7:30 PM
Registration opens
Ballroom Lobby

6:00 PM-8:00 PM
Welcoming Reception
Ballrooms I, II, and III

7:30 AM-4:00 PM
Registration opens
Ballroom Lobby

8:15 AM-8:30 AM
Welcoming Remarks
Emily Stone and *Dieter Armbruster*
Ballrooms I, II, and III

8:30 AM-9:30 AM
IP1 Diffraction of Atoms by Real, Complex and Imaginary Crystals of Light
Sir Michael Berry
Ballrooms I, II, and III

9:30 AM-10:00 AM
Coffee
Ballroom Lobby

10:00 AM-12:00 PM
MS1 Differential Delay Equations • *Ballroom I*
MS2 Synchronous Chaos and Invariant Manifolds • *Ballroom II*
MS3 Coping with Nonstationarity in Time Series Data • *Ballroom III*
MS4 Vortex Dynamics and Statistical Mechanics • *Magpie A/B*
MS5 Applications of Nonlinear Dynamics to Problems from Industry and Nature • *Wasatch A/B*
MS6 Ergodic Theory of Hyperbolic Dynamical Systems • *Golden Cliff*
MS7 Dynamics of the Complex Ginzburg-Landau Equation • *Maybird*
MS8 Fourth-Order Hamiltonian Systems and Variational Techniques in Dynamics • *Superior A*
MS9 Lattice Dynamical Systems • *Superior B*
MS10 Nonlinear Dynamics of Solids, Shells, and Rods • *White Pine*

12:00 PM-1:30 PM
Lunch
Attendees are on their own.

1:30 PM-2:30 PM
IP2 Analysis of a Class of Strange Attractors
Lai-Sang Young
Ballrooms I, II, and III

2:30 PM-3:00 PM
Coffee
Ballroom Lobby

3:00 PM-5:00 PM
CP1 Neurons • *Ballroom I*
CP2 Fluids • *Ballroom II*
CP3 Communication • *Ballroom III*
CP4 Applications I • *Magpie A/B*
CP5 Bifurcations with Symmetry • *Wasatch A/B*
CP6 Nonlinear Optics • *Golden Cliff*
CP7 Homoclinic Dynamics • *Maybird*
CP8 Materials • *Superior A*
CP9 Bifurcations in Nonsmooth Systems • *Superior B*

5:00 PM-7:00 PM
Dinner
Attendees are on their own.

Monday May 24

7:30 AM-4:00 PM
Registration opens
Ballroom Lobby

8:30 AM-9:30 AM
IP3 Dynamics of Microstructure/Flow Interactions
M. Gregory Forest
Ballrooms I, II, and III

9:30 AM-10:00 AM
Coffee
Ballroom Lobby

10:00 AM-12:00 PM
MS11 Chaos and Communication • *Ballroom I*
MS12 Applied Topology in Dynamics • *Ballroom II*
MS13 Dynamical Data Analysis in Biology • *Ballroom III*
MS14 Characterization of Spatiotemporal Chaos • *Magpie A/B*
MS15 Nonlinear Dynamics of Partial Differential Evolution Equations and Applications • *Wasatch A/B*
MS16 Numerical Analysis of Contact Problems Involving Friction • *Golden Cliff*
MS17 Analysis and Computation of Bistable Differential Equations • *Maybird*
MS18 Nonlinear Evolution, Separatrix Splitting, and Chaos in Dynamical Systems • *Superior A*
MS19 Flows of Liquid Crystalline Polymers • *Superior B*
MS20 Stability and Bifurcations of Relative Equilibria: Theory • *White Pine*

12:00 PM-1:30 PM
Lunch
Attendees are on their own.

1:30 PM-2:30 PM
IP4 Life at the Boundary of Chaos Theory and Nonequilibrium Statistical Mechanics
J. Robert Dorfman
Ballrooms I, II, and III

2:30 PM-3:00 PM
Coffee
Ballroom Lobby

3:00 PM-5:00 PM
MS21 Embeddings and Control — Part I of II • *Ballroom I*
MS22 Networks of Oscillators • *Ballroom II*
MS23 Mathematical and Computational Issues in Dynamics and Turbulence • *Ballroom III*
MS24 Qualitative Analysis of Nonlinear Partial Differential Equations • *Superior A*
MS25 Chaos and Irreversibility • *Maybird*
CP10 Geophysical Flows • *Magpie A/B*
CP11 Granular Flows • *Wasatch A/B*
CP12 Physiology • *Superior B*
CP13 Delay Equations • *Golden Cliff*
CP14 Hamiltonian Systems • *White Pine*

5:00 PM-6:00 PM
Business Meeting: SIAG/DS
Ballroom I

6:00 PM
Dinner
Attendees are on their own.

Tuesday May 25

7:30 AM-4:00 PM
Registration opens
Ballroom Lobby

8:30 AM-9:30 AM
IP5 Attractors in Evolutionary Equations
Jack Hale
Ballrooms I, II, and III

9:30 AM-10:00 AM
Coffee
Ballroom Lobby

10:00 AM-12:00 PM
MS26 Embeddings and Control — Part II of II • *Ballroom I*
MS27 Vibrating Granular Media • *Ballroom II*
MS28 Nonlinear Advection Diffusion Equations • *Ballroom III*
MS29 Bifurcations in Neuron Dynamics • *Magpie A/B*
MS30 Invariant Manifolds, Foliations and Applications • *Wasatch A/B*
MS31 Nonlinear Dynamics in Communication • *Golden Cliff*
MS32 Observation, Analysis and Modeling of Excitable Systems • *Maybird*
MS33 Pattern Formation in the Cahn-Hilliard Model — Part I of II • *Superior A*
MS34 New Models & Analysis of Noise-Sensitive Systems • *Superior B*
MS35 Stability and Bifurcations of Relative Equilibria: Applications • *White Pine*

12:00 PM-1:30 PM
Lunch
Attendees are on their own.

1:30 PM-2:30 PM
IP6 Finite Element Analysis of Nonsmooth Contact
Michael Ortiz
Ballrooms I, II, and III

2:30 PM-3:00 PM
Coffee
Ballroom Lobby

3:00 PM-5:00 PM
CP15 Data Analysis I and Spatiotemporal • *Ballroom I*
CP16 Mathematical Biology I • *Ballroom II*
CP17 Coupled Oscillators I • *Ballroom III*
CP18 Patterns I • Anisotropic • *Magpie A/B*
CP19 Control I • *Wasatch A/B*
CP20 Chaotic Maps I • *Golden Cliff*
CP21 Solitons I • *Maybird*
CP22 Numerics I • *Superior A*
CP23 Transport I • *Superior B*
CP24 PDEs I • *White Pine*

5:30 PM-7:00 PM
Dinner
Attendees are on their own.

7:30 PM-9:30 PM
Concurrent Sessions
CP25 Data Analysis II • *Ballroom I*
CP26 Mathematical Biology II • *Ballroom II*
CP27 Coupled Oscillators II • *Ballroom III*
CP28 Patterns II • Oscillators II • *Magpie A/B*
CP29 Control II • *Wasatch A/B*
CP30 Chaotic Maps II • *Golden Cliff*
CP31 Solitons II • *Maybird*
CP32 Numerics I • *Superior A*
CP33 Transport II • *Superior B*
CP34 PDEs II • *White Pine*

Wednesday May 26

7:30 AM-4:00 PM
Registration opens
Ballroom Lobby

8:30 AM-9:30 AM
IP7 Application of Dynamical Systems Theory to Spacecraft Trajectory Design Including GENESIS
Kathleen C. Howell
Ballrooms I, II, and III

9:30 AM-10:00 AM
Coffee
Ballroom Lobby

10:00 AM-12:00 PM
MS36 Topological Entropy and Average Expansion Rates • *Ballroom I*
MS37 Geometric Approximation Methods in Ocean Modeling • *Ballroom II*
MS38 Analysis and Application of Piecewise Smooth Dynamical Systems and Their Bifurcations • *Ballroom III*
MS39 Dynamics and Structures with Fractal Spectra • *Magpie A/B*
MS40 Space Missions and Dynamical Systems • *Wasatch A/B*
MS41 Dynamics of Scheduling Problems • *Golden Cliff*
MS42 Continuous Spectrum & Its Implications for Pattern Formation • *Maybird*
MS43 Calcium Dynamics: Oscillations, Sparks, & Waves • *Superior A*
MS44 Stochastic Stability of Dynamical Systems • *Superior B*
MS45 Geometric Analysis in Hydrodynamics • *White Pine*

12:00 PM-1:30 PM
Lunch
Attendees are on their own.

1:30 PM-2:30 PM
IP8 Quantitative Studies of the Fertilization Wave in Eggs
Joel Keizer
Ballrooms I, II, and III

2:30 PM-3:00 PM
Coffee
Ballroom Lobby

3:00 PM-5:00 PM
CP35 Data Analysis III • *Ballroom I*
CP36 Synchronization • *Ballroom II*
CP37 Pattern Formation in the Cahn-Hilliard Model-Part II • *Ballroom III*
CP38 Nonlinear Waves • *Magpie A/B*
CP39 Applications II • *Wasatch A/B*
CP40 Applications III • *Golden Cliff*
CP41 Forced Biosystems • *Maybird*
CP42 Patterns III • *Superior A*
CP43 Vortex Dynamics • *Superior B*
CP44 Polymers • *White Pine*

5:00 PM-7:00 PM
Dinner
Attendees are on their own.

7:00 PM-8:00 PM
Poster presenters begin setting up their displays. Set-up to be completed by 8:00 PM.

8:00 PM-10:00 PM
Poster Session and Dessert Reception

10:00 PM
Posters are removed from the boards.

Thursday May 27

7:30 AM-10:00 AM
Registration opens
Ballroom Lobby

8:30 AM-9:30 AM
IP9 DNA Evolution and Computation
Albert J. Libchaber
Ballrooms I, II, and III

9:30 AM-10:00 AM
Coffee
Ballroom Lobby

10:00 AM-12:00 PM
MS46 Modeling of Chaotic Systems • *Ballroom I*
MS47 Complex Synchronization in Neuroscience • *Ballroom II*
MS48 Chaotic Advection in Temporally Chaotic Flows • *Ballroom III*
MS49 Applied Dynamics and Invariant Manifolds • *Magpie A/B*
MS50 Invariant Manifolds in Oscillation Problems • *Wasatch A/B*
MS51 Nonlinear Dynamics in Frontal Polymerization • *Golden Cliff*
MS52 Set-Oriented Methods in Study of Dynamical Systems • *Maybird*
MS53 Dynamics of Tethered Satellite Systems • *Superior A*
MS54 Bifurcation and Euclidean Symmetry • *Superior B*
MS55 Dynamics and Nonlinear ODEs in Industrial Applications • *White Pine*

12:15 PM-1:15 PM
IP10 Stability and Instability in Hamiltonian Dynamics
Zhihong Jeff Xia
Ballrooms I, II, and III

1:15 PM
Conference adjourns

Key to Abbreviations and Symbols

CP = Contributed Presentations
IP = Invited Plenary Presentations
MS = Minisymposium
= Coffee Breaks
= Lunch and Dinner Breaks
= Poster Session

Audio-Visual Requirements

Two standard overhead projectors and two screens will be provided in the plenary session room. One overhead projector and one screen will be provided in each of the parallel session rooms. Speakers with special audiovisual equipment needs must inform SIAM of their specific requirements by Wednesday, April 21, 1999. If we do not hear from speakers by that date, it is understood that standard overhead projectors are all that is needed. Wednesday, April 21, 1999 is a firm deadline. Last minute requests cannot be honored. If a speaker sends a request for a special audiovisual equipment and decides not to use the requested equipment after it has been installed, or does not show up to give her/his presentation, the speaker is responsible for paying the rental fee. Some examples of special audiovisual equipment and rental fees are:

LCD Panel	$300
35mm Slide Projector	$50
Video Projector	$550
1/2" VHS VCR	$65
26" Data Monitor	$300
Shure Mixer	$25
Xenon 35mm Projector	$200
Data Projector	$600

For papers with multiple authors, ***the speaker is shown in italics***, if known at press time.

Time Allotted for Each Type of Presentation

- Contributed Presentations (CP) are 15 minutes plus 5 minutes for audience questions
- Invited Plenary Presentations (IP) are 50 minutes plus 5 minutes for audience questions
- Minisymposium Presentations (MS) are 25 minutes plus 5 minutes for audience questions
- Poster Sessions are 120 minutes

Important Notice to Poster Presenters

Poster presenters are asked to set up their poster materials at 7:00 PM on Wednesday, May 26 in Ballrooms I, II and III. All poster materials must be up on the poster boards by 8:00PM. The poster session and dessert reception will officially open at 8:00 PM. All poster displays must be removed immediately at the end of the session at 10:00 PM. SIAM is not responsible for any materials left on the boards and discarded after 10:00 PM on Wednesday, May 26.

Box Lunch Information

For those attendees who have purchased box lunches in advance, your lunch tickets are in your pre-registration packet. Those who want to purchase box lunches on-site, each lunch costs $12.00 per day. Buy your lunch tickets at the SIAM registration desk. Box lunches are available Sunday, Monday, Tuesday and Wednesday.

Invited Presentations

Sunday, May 23

8:30 AM-9:30 AM

IP1 • Diffraction of Atoms by Real, Complex and Imaginary Crystals of Light

Sir Michael Berry, *H. H. Wills Physics Laboratory, University of Bristol, United Kingdom*

Sunday, May 23

1:30 PM-2:30 PM

IP2 • Analysis of a Class of Strange Attractors

Lai-Sang Young, *Department of Mathematics, University of California, Los Angeles; and Courant Institute of Mathematical Sciences, New York University*

Monday, May 24

8:30 AM-9:30 AM

IP3 • Dynamics of Microstructure/Flow Interactions

M. Gregory Forest, *Department of Mathematics, University of North Carolina, Chapel Hill*

Monday, May 24

1:30 PM-2:30 PM

IP4 • Life at the Boundary of Chaos Theory and Nonequilibrium Statistical Mechanics

J. Robert Dorfman, *Institute for Physical Science and Technology, University of Maryland, College Park*

Tuesday, May 25

8:30 AM-9:30 AM

IP5 • Attractors in Evolutionary Equations

Jack Hale, *School of Mathematics, Georgia Institute of Technology*

Tuesday, May 25

1:30 PM-2:30 PM

IP6 • Finite Element Analysis of Nonsmooth Contact

Michael Ortiz, *Graduate Aeronautical Laboratories, California Institute of Technology*

Wednesday, May 26

8:30 AM-9:30 AM

IP7 • Application of Dynamical Systems Theory to Spacecraft Trajectory Design Including GENESIS

Kathleen C. Howell, *Department of Aeronautics and Astronautics, Purdue University, West Lafayette*

Wednesday, May 26

1:30 PM-2:30 PM

IP8 • Quantitative Studies of the Fertilization Wave in Eggs

Joel Keizer, *Institute of Theoretical Dynamics, University of California, Davis*

Thursday, May 27

8:30 AM-9:30 AM

IP9 • DNA Evolution and Computation

Albert J. Libchaber, *Center for Studies in Physics and Biology, Rockefeller University*

Thursday, May 27

12:15 PM-1:15 PM

IP10 • Stability and Instability in Hamiltonian Dynamics

Zhihong Jeff Xia, *Department of Mathematics, Northwestern University*

All invited plenary presentations will take place in Ballrooms I, II, and III.

General Information

1999 SIAM Conference on Dynamical Systems

Registration Fees

SIAG/DS Member*	$195
SIAM Member	$210
Non-Member	$270
Student (after May 14, 1999)	$45

* SIAM Activity Group on Dynamical Systems

Forms of Payment

SIAM accepts American Express, MasterCard, Visa or checks as a form of payment.

Registration Fee Includes

- Welcoming Reception
- Coffee and Refreshments
- Poster Session and Dessert Reception
- Admission to all Technical Sessions
- Final Program and Abstract Booklet

Cancellation Fee

Before May 3, 1999 = Full Refund
May 4-14, 1999 = $50.00 Cancellation Fee
After May 14, 1999 = No Refund

Registration Hours

The SIAM registration desk will be located in the Cliff Lodge Ballroom Lobby. It is open during the following times:

Saturday, May 22	6:00 PM-7:30 PM
Sunday, May 23	7:30 AM-4:00 PM
Monday, May 24	7:30 AM-4:00 PM
Tuesday, May 25	7:30 AM-4:00 PM
Wednesday, May 26	7:30 AM-4:00 PM
Thursday, May 27	7:30 AM-10:00 AM

Box Lunches

Box lunches are available Sunday through Wednesday. Each lunch costs $12. There will be no prorated fees. No refunds will be issued after Friday, May 14, 1999. If your preregistration payment arrives at SIAM after the conference has started, that payment will be returned to you and your on-site registration will be processed.

E-mail

SIAM cannot offer e-mail access for individual attendees. We suggest you bring your own laptop computer and use hotel facilities. If you do not have your own personal laptop computer, the hotel business office offers this service at a nominal fee.

SIAM Membership

Non-SIAM members are encouraged to join SIAM to obtain the member rate for conference registration and enjoy the additional benefits of SIAM membership. As a member, you will receive free subscriptions to *SIAM Review* and *SIAM News*, and substantial discounts on SIAM books and journal subscriptions. Join SIAM by contacting Customer Service for an application form at:

On-line: http://www.siam.org/about/memapp99.htm
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Fax: 1-215-386-7999
E-mail: service@siam.org
Mail: SIAM
3600 University City Science Center
Philadelphia, PA 19104-2688 USA

SIAM Corporate Members

Non-member attendees who are employed by the following organizations are entitled to the SIAM member rate:

- Aerospace Corporation
- AT&T Laboratories–Research
- Bell Laboratories, Lucent Technologies
- Bellcore
- The Boeing Company
- E. I. DuPont de Nemours & Company
- Eastman Kodak Company
- Exxon Research and Engineering Company
- General Motors Corporation
- IBM Corporation
- ICASE
- IDA Center for Communications Research, La Jolla
- IDA Center for Communications Research, Princeton
- Institute for Defense Analyses, Center for Computing Sciences
- MacNeal-Schwendler Corporation
- Mathematical Sciences Research Institute
- Microsoft Corporation
- National Security Agency
- NEC Research Institute
- Oak Ridge National Laboratory, managed by the Lockheed Martin Energy Research Corporation for the Department of Energy
- Pacific Northwest National Laboratory, operated by Battelle
- Schlumberger-Doll Research
- Silicon Graphics, Inc.

Conference Tabletop Exhibitors

- Baltzer Science Publishers
- John Wiley & Sons
- Springer-Verlag
- VSP International Publishers

Hotel Facilities

The Cliff Lodge is a full-service modern hotel with roof-top outdoor heated swimming pool, three whirlpool hot tubs, and health spa. The Cliff Spa occupies the 9th and 10th floors of the Cliff Lodge and offers numerous services: massages, sauna, aerobics, and weight room. Spa facilities are available to SIAM attendees 18 years of age and older for a charge of $10 per day. Guests staying longer than three days can purchase a $30 pass valid for your entire stay. A wide variety of shops and boutiques are also available in the Snowbird Center and the Cliff Lodge. There are three tennis courts at Snowbird. For those who enjoy hiking and trekking, maps of the Snowbird area are available at the Activities Center. Mountain bicycles are available for rent.

Restaurants and Lounges

The Mexican Keyhole serves traditional Mexican entrees and drinks. Elegant dining can be found in the Aerie, a glass-enclosed rooftop restaurant with views of the mountains on all sides. Snowbird Village is the home of eight additional restaurants and lounges.

Parking at the Conference

There is complimentary valet parking available at the Cliff Lodge.

Telephone Messages

The telephone number of the Snowbird Resort and Conference Center is 1-800-453-3000 (US only) for reservations and 1-801-742-2222 to reach attendees. The hotel will either connect you with the SIAM registration desk or forward a message to the attendee's room.

Transportation Assistance

If you need assistance when booking your flight home, or in case of emergency, call 1-800-787-4315. Uniglobe Travel has 24 hour assistance available for all of its clients nationwide. If you need to take advantage of this free service, call 1-800-878-4315.

Ground Transportation from and to the Airport

Canyon Transportation, Inc. is a shuttle service that transports people between the airport and Snowbird. **You must make a reservation for the shuttle in advance.** Do this by calling Canyon Transportation at 1-800-255-1841, or by making a reservations with Snowbird's Central Reservations office. Remember to make a reservation for your departure from the conference. Canyon Transportation requires that you make a shuttle reservation 24 hours prior to your flight's scheduled departure.

PROGRAM

Fifth SIAM Conference on

APPLICATIONS of DYNAMICAL SYSTEMS

May 23-27, 1999

Snowbird Ski and Summer Resort • Snowbird, Utah

Saturday, May 22

Saturday, May 22

Registration Open

6:00 PM-7:30 PM

Location: Ballroom Lobby

Saturday, May 22

Welcoming Reception

6:00 PM-8:00 PM

Room: Ballrooms I, II & III

Sunday, May 23

For papers with multiple authors, *the speaker is shown in italics,* if known at press time.

Sunday, May 23

Registration Open

7:30 AM-4:00 PM

Location: Ballroom Lobby

Sunday, May 23

Welcoming Remarks

8:15 AM-8:30 AM

Room: Ballrooms I, II & III

Emily Stone, Chair, Department of Mathematics and Statistics, Utah State University; and Dieter Armbruster, Co-chair, Department of Mathematics, Arizona State University

Sunday, May 23

IP1

Diffraction of Atoms by Real, Complex and Imaginary Crystals of Light

8:30 AM-9:30 AM

Room: Ballrooms I, II & III

Chair: Steven H. Strogatz, Cornell University

Quantum atoms interact with light through a spatially-varying sinusoidal potential. This diffracts the atoms into a series of Bragg beams (previously studied for the diffraction of light by ultrasound). For real (nondissipative) potentials, classical motion is integrable; nevertheless, the semiclassical limit for thick crystals is ergodic, and caustics give large "twinkling" fluctuations. The potential can be made arbitrarily complex by adjusting the detuning. If it is purely imaginary, diffraction reveals nonhermitian degeneracies of the Bloch waves, and the distribution of intensities is dominated by complex rays rather than caustics. For complex potentials proportional to exp(iKx), the intensities can be calculated exactly, giving lopsided diffraction—and a dramatic violation of Friedel's law of crystallography, even a fractal.

Sir Michael Berry
H. H. Wills Physics Laboratory
University of Bristol, United Kingdom

Sunday, May 23

Coffee

9:30 AM-10:00 AM

Location: Ballroom Lobby

10:00 AM-12:00 PM Concurrent Sessions

Sunday, May 23

MS1

Differential Delay Equations: Theory and Applications

10:00 AM-12:00 PM

Room: Ballroom I

This minisymposium will focus on recent developments in the theory and applications of differential-delay equations. The speakers will describe applications from high-dimensional systems (neural networks, networks of lasers) and engineering applications such as cutting tool dynamics. They will discuss theoretical studies involving traveling waves and bifurcation and anticipate that the presentations will appeal to researchers with an interest in infinite dimensional dynamical systems and to those concerned with the applications.

Organizer: John Mallet-Paret
Brown University

10:00-10:25 Regenerative Effect and Chatter: An Analytical Study
Yan Liang and *N. Sri Namachchivaya,* University of Illinois, Urbana-Champaign

10:30-10:55 Nonexpansive Periodic Operators in $\ell_1(Z)$ and Super-high-frequency Solutions of a Discontinuous Differential-Delay Equation
Roger D. Nussbaum, Rutgers University; and Eugenii Shustin, Tel Aviv University, Israel

11:00-11:25 Dynamics of Time Delayed Ring Laser Systems
Rajarshi Roy, Georgia Institute of Technology

11:30-11:55 Delay and Traveling Waves in Reaction-Diffusion Equations
Xingfu Zou, Georgia Institute of Technology

Sunday, May 23

MS2

Synchronous Chaos and Invariant Manifolds

10:00 AM-12:00 PM

Room: Ballroom II

The phenomenon of synchronization of chaotic systems is interesting both because of potential applications and as a model for complex, but coherent motion in spatially extended systems, for example, biological systems. Recent work has now linked the phenomenon of synchronization to the more general one of motion on an invariant manifold. This symposium covers very recent results: (1) the use of k-hyperbolic manifolds to generate conditions for synchronization, (2) the possibility of failure of numerical shadowing of synchronous trajectories in some systems, (3) two attractor communication and (4) formulation of sufficient conditions for robust synchronization in real systems.

Organizer: Louis M. Pecora
U.S. Naval Research Laboratory

10:00-10:25 Invariant Manifolds and Chaotic Synchronization
Kresimir Josic, Pennsylvania State University and Boston University

10:30-10:55 Unstable Dimension Variability and Modeling of Coupled Chaotic Oscillators
Ying-Cheng Lai, University of Kansas, Lawrence; and Celso Grebogi, University of Maryland, College Park

11:00-11:25 Using Two-Attractor Chaotic Systems for Communication
Tom Carroll, U.S. Naval Research Laboratory and Louis M. Pecora, Organizer

11:30-11:55 Experimental Evaluation of Several Proposed Criteria for Synchronization
Jonathan Blakely and Daniel Gauthier, Duke University

Sunday, May 23

MS3

Coping with Nonstationarity in Time Series Data from Nonlinear

10:00 AM-12:00 PM

Room: Ballroom III

Nonstationarity is one of the most relevant open problems in time series analysis. For many systems, nonstationarity is an intrinsic feature representing the time variation of the system's dynamics. The latter point of view leads to powerful new concepts to detect, analyze and cope with nonstationarity. Some of them, such as cross-prediction errors and recurrence plots, rely on deterministic structure underlying the data. Instead of segmenting data sets into almost stationary phases, the implicit reconstruction of the values of drifting parameters can restore stationarity requirements for applications such as noise reduction and signal classification. Nonlinear time series analysis has become a relevant tool for inverse problem. A new approach towards the problem of nonstationarity is of high relevance to broader applications of these methods, e.g. in the treatment of medical data, speech processing, and failure prediction in technical devices. In this minisyposium, the speakers will present relevant recent progress in this area which could stimulate a new philosophy, and consider certain types of nonstationarity as part of the (potentially nondeterministic) dynamics and treat the series as an entity.

Organizers: Holger Kantz
Max-Planck Institut für Physik Komplexer Systeme, Dresden, Germany

Thomas Schreiber
Universität Wuppertal, Germany

10:00-10:25 Testing Stationarity in Time Series
Annette Witt, Jürgen Kurths, and Arkadi Pikovsky, Universität Potsdam, Germany

10:30-10:55 Recurrence Plots Revisited
Martin Casdagli, Prediction Company, Santa Fe, New Mexico

11:00-11:25 Clusters as a Basis for the Study of Non-Stationary Time Series
Thomas Schreiber, Organizer

11:30-11:55 Coping with Nonstationarity by Over-Embedding
Holger Kantz, Organizer; Rainer Hegger, Max-Planck Institut für Physik Komplexer Systeme, Dresden, Germany; and Thomas Schreiber, Organizer

Sunday, May 23

MS4

Vortex Dynamics and Statistical Mechanics on Spheres

10:00 AM-12:00 PM

Room: Magpie A/B

This minisymposium will focus on recent developments in vortex dynamics and statistical mechanics on spherical surfaces. The work is motivated by applications in geophysical fluid dynamics where coherent structures, such as atmospheric cyclones or oceanographic eddies, persist over long times and travel over such large distances, that the spherical geometry of the earth becomes important. The systems are modeled by the Euler equations from two-dimensional fluid mechanics, hence Hamiltonian techniques are widely used. For most applications, viscous effects can be ignored, although effects of rotation are also generally considered important. The speakers in this minisymposium will provide a snapshot of current activity in this area.

Organizers: Paul K. Newton
University of Southern California

Chjan C. Lim
Rensselaer Polytechnic Institute

10:00-10:25 Integrable Vortex Dynamics on a Sphere
Paul K. Newton, Organizer

10:30-10:55 Equilibrium Statistics and Dynamics of Point Vortices on a Rotating Sphere
Chjan C. Lim, Organizer

11:00-11:25 Discrete Euler-Poincaré and Lie-Poisson Equations
Sergey Pekarsky and *Jerrold Marsden,* California Institute of Technology

11:30-11:55 Finite Symmetry Methods for *N* Identical Vortices on the Sphere
James Montaldi, Institut Non-Linéaire de Nice, Valbonne, France

Sunday, May 23

MS5

Applications of Nonlinear Dynamics to Problems from Industry and Nature

10:00 AM-12:00 PM

Room: Wasatch A/B

This minisymposium will focus on applications of nonlinear dynamics to industrial problems. Although the speakers will discuss a broad range of work, all of the talks satisfy three criteria: (1) the problem originated from outside the nonlinear dynamics community, (2) the methods used to successfully solve the problem come from the nonlinear dynamics community, and (3) the criteria used to measure success come from the community that originated the problem. The last criterion is important because the originator of a problem often gauges success using criteria that are different from those used by the nonlinear dynamics community.

Organizer: Reggie Brown
College of William and Mary

10:00-10:25 Generating Random Numbers Via Deterministic Chaos
Ljupco Kocarev and Toni Stojanovski, College of William and Mary

10:30-10:55 Constructing Transportable Behavioral Models of Nonlinear Electronic Devices
David M. Walker, Hewlett Packard Laboratories, and College of William and Mary; Reggie Brown, Organizer; and Nicholas B. Tufillaro, College of William and Mary, and Hewlett Packard Laboratories

11:00-11:25 Chaotic Dynamics and Modeling of Power System Loads
Eric Kostelich, Gerald Heydt, and Efrain O'Neill, Arizona State University

11:30-11:55 Cargo Transfer with Shipboard Cranes: Control, Prediction and Simulation
Brian R. Hunt, University of Maryland, College Park

Sunday, May 23

MS6

Ergodic Theory of Hyperbolic Dynamical Systems

10:00 AM-12:00 PM

Room: Golden Cliff

The ergodic theory of hyperbolic dynamical systems has been fundamental to the understanding of "chaotic" systems and to the development of a rigorous foundation for statistical mechanics. This minisymposium will address recent results for systems that are not uniformly hyperbolic and in particular results on stable ergodicity which have led to the provision of a large class of models that retain strong mixing properties under deterministic perturbation. These models arise naturally in applications with Lie group symmetry.

Organizer: Matthew J. Nicol
UMIST, Manchester, United Kingdom

10:00-10:25 Ergodic Theory of Equivariant Diffeomorphisms
Michael Field, University of Houston

10:30-10:55 Lyapunov Exponents and Partially-Hyperbolic Systems
Amie Wilkinson, Northwestern University

11:00-11:25 Ergodic Properties of a Class of Skew Products
Charles Walkden, University of Manchester, United Kingdom

11:30-11:55 The Dynamics of a Class of Nonuniformly Hyperbolic Attractor of Solenoid Type
Don Wang, University of California, Los Angeles

Sunday, May 23

MS7

Dynamics of the Complex Ginzburg-Landau Equation: Experiment and Theory

10:00 AM-12:00 PM

Room: Maybird

The Complex Ginzburg-Landau (CGL) equation and its variants describe a wide variety of physical phenomena. The rich dynamics coupled with the relative simplicity of the equations create a fertile landscape for studying the dynamics of nonlinear PDEs and the physical systems they describe in this minisymposium. Experimentalists (R. Ecke, M. Dennin) will discuss the determination of CGL coefficients and evidence for periodic and chaotic behavior in two fluid systems. Theorists (H. Riecke, D. Egolf) will describe behavioral transitions, the role of topological defects, and Langevin equation descriptions of long-wavelength behavior in spatiotemporally chaotic CGL equations.

Organizer: David A. Egolf
Los Alamos National Laboratory

10:00-10:25 Transition from Ordered to Disordered Defect Chaos
Hermann Riecke, Northwestern University; and Glen D. Granzow, Idaho State University

10:30-10:55 Spatiotemporal Chaos in Electroconvection: An Application of Coupled CGL Equations
Michael Dennin, University of California, Irvine

11:00-11:25 The Complex Ginzburg-Landau Equation: Connection to Physical Experiment
Robert E. Ecke, Los Alamos National Laboratory

11:30-11:55 Long Wavelength Behavior in the 1D Complex Ginzburg-Landau Equation
David A. Egolf, Organizer

Sunday, May 23

MS8

Fourth-Order Hamiltonian Systems and Variational Techniques in Dynamics

10:00 AM-11:30 AM

Room: Superior A

Fourth-order Hamiltonian systems arise in many physical models from areas such as phase transitions, optics, and nonlinear elasticity. These systems can be studied using variational methods or techniques from the theory of dynamical systems. In many cases, a combination of ideas from both areas has provided the most successful analysis. The speakers in this minisymposium will discuss these approaches and explore applications and related problems, such as pattern formation in evolution equations and elliptic systems.

Organizers: William Kalies
Florida Atlantic University

Robert VanderVorst
Georgia Institute of Technology

10:00-10:25 Snaking Curves of Multibumps, Degenerate Hamiltonian Hopf Bifurcation and Cellular Buckling of Long Structures
Alan Champneys and Patrick D. Woods, University of Bristol, United Kingdom

10:30-10:55 The Saddle-Focus Induced Homotopy Classes and Their Action Minimizing Orbits for Hamiltonian Systems with Two Degrees of Freedom
Jaroslaw Kwapisz, Montana State University

11:00-11:25 An Elliptic Equation with Spike Solutions Concentrating at Local Minima of the Laplacian
Gregory S. Spradlin, United States Military Academy

Sunday, May 23

MS9

Lattice Dynamical Systems: Theory and Applications

10:00 AM-12:00 PM

Room: Superior B

Lattice Dynamical Systems (LDS) emerged since mid-eighties as a new tool to study space-time dynamics. LDS also serve as an extremely useful tool for numerical modeling of spatially extended dynamical systems. More recently LDS were successfully used for a control of chaos in extended systems and for the studies of selforganization in spatially discrete systems. The speakers will discuss thermodynamics of LDS, control of extended dynamical systems, and order-chaos transitions and collective behavior in LDS.

Organizer: Leonid A. Bunimovich
Georgia Institute of Technology

10:00-10:25 Bifurcations of Localized Structures in Lattice Systems
Leonid A. Bunimovich, Organizer

10:30-10:55 Collective Behavior of Lattices of Strongly-Coupled Chaotic Maps
Hugues Chaté and Anaël Lemaître, Centre d'Etudes de Saclay, France

11:00-11:25 Symmetry and Control of Extended Dynamical Systems
Roman O. Grigoriev, University of Chicago

11:30-11:55 Existence, Uniqueness, and Smooth Dependence of Thermodynamic Limits of SRB Measures
Miaohua Jiang, Wake Forest University

Sunday, May 23

MS10

Nonlinear Dynamics of Solids, Shells, and Rods

10:00 AM-12:30 PM

Room: White Pine

The speakers in this minisymposium will address theoretical and computational aspects of nonlinear dynamics of solids especially structures such as shells and rods used by engineers. Energy-momentum and dissipative integration schemes, reduction methods, existence of inertial manifolds, chaotic and regular motion in shells are some aspects of the minisymposium: (1) Since the stability property of time integration schemes become very important when dealing with very large systems, robust integration schemes have to be constructed. Efforts recently taken in developing mechanical integrators that preserve the essential features of the mechanical system, e.g., the momemtum, the energy, or the symplectic structure, will be focused on. (2) Several ideas of extending some techniques and applications of reduction methods that were originally developed in the context of Fluid Mechanics, to the context of the Theory of Elasticity and Solid Structures will be given. Applications to mechanical structures of the POD method, the nonlinear Galerkin or the post processed Galerkin method to approximate Inertial Manifolds, will be discussed. (3) Birfurcations, chaotic and free large over-all motion of such structures are of interest and will be taken as examples.

Organizers: Peter Wriggers
Darmstadt University of Technology, Germany

Carlo Sansour
University of Karlsruhe, Germany

10:00-10:25 Postprocessing Galerkin Methods
Edriss Titi, University of California, Irvine

10:30-10:55 Nonlinear Oscillations of a Fluid Conveying Tube with an End Mass
Alois Steindl, Hans Troger, and Bernhard Albrecht, Vienna University of Technology, Austria

11:00-11:25 Time-Stepping Algorithms with Controllable High-Frequency Dissipation for Nonlinear Dynamics
Francisco Armero and Ignacio Romero, University of California, Berkeley

11:30-11:55 The Post-Processed Galerkin Method Applied to Nonlinear Shell Vibrations
Carlo R. Laing, University of Pittsburgh; and Allan McRobie, Cambridge University, United Kingdom

12:00-12:25 Geometric Exact Models, Energy-Momentum Methods, and Active Degrees of Freedom for the Dynamics of Shells and Rods
Carlo Sansour and Peter Wriggers, Organizers; and Jamal Sansour, University of Hannover, Germany

Sunday, May 23

Lunch

12:00 PM-1:30 PM

Attendees are on their own.

Sunday, May 23

IP2

Analysis of a Class of Strange Attractors

1:30 PM-2:30 PM

Room: Ballrooms I, II & III

Chair: Konstantin Mischaikow, Georgia Institute of Technology

The speaker will introduce a new class of attractors and present a multi-faceted analysis of their dynamical properties. This class includes as special cases some familiar objects such as the Axiom A solenoid, Henon attractors and dissipative twist maps. The speaker will discuss results on the chaotic behavior, global geometry, symbolic representation, topological complexity and statistical properties of these attractors.

Lai-Sang Young
Department of Mathematics University of California, Los Angeles; and Courant Institute of Mathematical Sciences, New York University

Sunday, May 23

Coffee

2:30 PM-3:00 PM

Location: Ballroom Lobby

3:00 PM-5:00 PM
Concurrent Sessions

Sunday, May 23

CP1

Neurons

3:00 PM-5:00 PM

Room: Ballroom I

Chair: Robert M. Miura, University of British Columbia, Vancouver, Canada

3:00-3:15 Rate-Dependent Activity in Excitable Cells
Jennifer S. Enns-Ruttan and *Robert M. Miura*, University of British Columbia, Vancouver, Canada

3:20-3:35 Understanding Interspike Interval Variability
Tay Netoff, George Mason University and George Washington University; Paul So, Bruce Gluckman, Joseph T. Francis, and Steven J. Schiff, George Mason University

3:40-3:55 Dimension Estimation for Seizure Prediction and Localization
Kristin Jerger, George Washington University Medical Center and George Mason University

4:00-4:15 Synchronous Behavior of Two Coupled Biological Neurons
Robert C. Elson, University of California, San Diego; Allen I. Selverston, Instituto de Neurobiologica, Old San Juan, Puerto Rico; Ramon Huerta, Universidad Autonoma de Madrid, España; *Nikolai F. Rulkov*, Mikhail I. Rabinovich, and Henry D. I. Abarbanel, University of California, San Diego

4:20-4:35 Genesis of Coherent Structures in a Discrete Chaotic Neural Medium
Mikhail I. Rabinovich, *Joaquín J. Torres*, Pablo Varona and Ramón Huerta, University of California, San Diego; and Patrick Weidman, University of Colorado, Boulder

4:40-4:55 A Study of Oscillatory Activity in the Model of the Septo-Hippocampal System
Roman Borisyuk and Michael Denham, University of Plymouth, United Kingdom

Sunday, May 23

CP2

Fluids

3:00 PM-5:00 PM

Room: Ballroom II

Chair: Charles R. Doering, University of Michigan, Ann Arbor

3:00-3:15 Laminar and Turbulent Energy Dissipation in a Shear Boundary Layer with Suction
Charles R Doering and Rodney A. Worthing, University of Michigan, Ann Arbor; and Edward A. Spiegel, Columbia University

3:20-3:35 Time-Dependent Flow Regimes in Two-Phase Flows and Compressible Fluids
Jayati Johri and Benjamin J. Glasser, Rutgers, The State University of New Jersey

3:40-3:55 Spatial and Temporal Resonances in a Periodically Forced Extended System
J. M. Lopez, Arizona State University; and F. Marques, Universitat Politecnica de Catalunya, Barcelona, España

4:00-4:15 Asymptotic Regime of the Rayleigh-Taylor Instability in the Large-Time Limit
Toshio Yoshikawa and Alexander M. Balk, University of Utah

4:20-4:35 Connecting Double Points in Rayleigh-Bénard Convection
John H. Bolstad, Lawrence Livermore National Laboratory

4:40-4:55 Stability Analysis of Perturbed Plane Couette Flow
Laurette Tuckerman, LIMSI-CNRS, Orsay, France; and Dwight Barkley, University of Warwick, United Kingdom

Sunday, May 23

CP3

Communication

3:00 PM-5:00 PM

Room: Ballroom III

Chair: Ned J. Corron, Dynetics, Inc., Huntsville, Alabama

3:00-3:15 Chaos Communications Using Virtual Synchronization
Ned J. Corron, Dynetics, Inc., Huntsville, Alabama

3:20-3:35 Security Issues in Chaotic Communications
Andrew T. Parker and *Kevin M. Short,* University of New Hampshire

3:40-3:55 Multiple-Scale Averaging and Optimization of Amplifier Placement in Multi-Channel Dispersion-Managed Soliton Transmission
Brian Marks, William L. Kath, and Tian-Shiang Yang, Northwestern University; and Sergei K. Turitsyn, Aston University, Birmingham, United Kingdom

4:00-4:15 Theory of Wavelength Division Multiplexing in Fiber Links with Dispersion Management
Ildar Gabitov, Los Alamos National Laboratory

4:20-4:35 Polarization-Based Laser Communication Schemes
John B. Geddes and Kevin M. Short, University of New Hampshire

4:40-4:55 Premature Synchronisation in Coupled Maps
Giovanni Santoboni and Steven R. Bishop, University College London, United Kingdom; and Rua Murray, University of Victoria, Canada

Sunday, May 23

CP4

Applications I: Geophysical and Industrial

3:00 PM-4:40 PM

Room: Magpie A/B

Chair: Kay A. Robbins, University of Texas, San Antonio

Geophysical

3:00-3:15 Symmetry-Breaking Bifurcations in a Hopf/Steady-State Mode Interaction in Three-Dimensional Magnetoconvection
Jonathan H. P. Dawes, University of Cambridge, United Kingdom

3:20-3:35 Double Hopf Bifurcation in a Geophysical Fluid Dynamics Model
Gregory M. Lewis and Wayne Nagata, University of British Columbia, Vancouver, Canada

Industrial

3:40-3:55 Thermo-Acoustic Instabilities in Aeropropulsion Systems
D. Dane Quinn, The University of Akron

4:00-4:15 Singular Poincaré-Andronov-Hopf Bifurcation to Relaxation Oscillations During High-Speed Metal Cutting
Timothy J. Burns and Matthew A. Davies, National Institute of Standards and Technology, Gaithersburg

4:20-4:35 Visual Interpretation of Transitions in Spatiotemporal Systems
Kay A. Robbins, University of Texas, San Antonio

Sunday, May 23

CP5

Bifurcations with Symmetry

3:00 PM-5:00 PM

Room: Wasatch A/B

Chair: Martin Golubitsky, University of Houston

3:00-3:15 Chaotic Direction-Reversing Waves

Edgar Knobloch and Jeff Moehlis, University of California, Berkeley; and *Adam S. Landsberg,* Claremont McKenna, Scripps, and Pitzer Colleges

3:20-3:35 Bursts in Oscillatory Systems with Broken D_4 Symmetry

Jeff Moehlis and Edgar Knobloch, University of California, Berkeley

3:40-3:55 A Model of Central Pattern Generators for Quadruped Locomotion

Pietro-Luciano Buono, University of Ottawa, Canada; Martin Golubitsky, University of Houston; Ian Stewart, University of Warwick, United Kingdom; and J. J. Collins, Boston University

4:00-4:15 Doubly Forced Oscillators

Bruce B. Peckham, University of Minnesota, Duluth; and Ioannis G. Kevrekidis, Princeton University

4:20-4:35 Heteroclinic Cycles in Networks of Cells with D_n- Symmetry

Pietro-Luciano Buono, University of Ottawa, Canada; *Martin Golubitsky* and Antonio Palacios, University of Houston

4:40-4:55 Normal Forms via Non-Normal Means

B. D. Coller and R. Chamara, University of Illinois, Chicago

Sunday, May 23

CP6

Nonlinear Optics

3:00 PM-5:00 PM

Room: Golden Cliff

Chair: William L. Kath, Northwestern University

3:00-3:15 Dynamics of Wavelength-Division-Multiplexed Transmission of Return-to-Zero Pulses in Dispersion-Managed Optical Fibers

Tian-Shiang Yang and *William L. Kath,* Northwestern University; and Stephen G. Evangelides Jr., Tyco Submarine Systems Ltd. Laboratories

3:20-3:35 Estimating Parameters in Laser Dynamics

Jens Timmer and Werner Horbelt, University of Freiburg, Germany; and Martin Bünner, Marco Ciofini, and Riccardo Meucci, Istituto Nazionale di Ottica, Florence, Italy

3:40-3:55 Bi-Instability and Ultrasubharmonics in a Modulated Laser

Thomas W. Carr, Southern Methodist University; and Ira B. Schwartz, Naval Research Laboratory

4:00-4:15 Dynamics of Low-Amplitude Resonant Light-Matter Interaction

Julie A. Byrne, Rensselaer Polytechnic Institute

4:20-4:35 Controlling Resonant Wave Interactions to Enhance Frequency Conversion in Nonlinear Optics

Gregory G. Luther, Northwestern University

4:40-4:55 Self-Pulsations of a Lasers with Saturable Absorber

Johan L.A. Dubbeldam, Vrije Universiteit, The Netherlands; and *Bernd Krauskopf,* University of Bristol, United Kingdom

Sunday, May 23

CP7

Homoclinic Dynamics

3:00 PM-5:00 PM

Room: Maybird

Chair: Richard Haberman, Southern Methodist University

3:00-3:15 Slow Passage Through a Saddle-Center Bifurcation

Richard Haberman, Southern Methodist University

3:20-3:35 Homoclinic Bifurcations and Chaos in the Presence of a Center Manifold

Joseph Gruendler, North Carolina A&T State University

3:40-3:55 Homoclinic and Heteroclinic Orbits in Cylinder Buckling

Gabriel Lord, National Physical Laboratory, Teddington, United Kingdom; Alan Champneys, University of Bristol, United Kingdom; and Giles Hunt, University of Bath, United Kingdom

4:00-4:15 Homoclinic and Heteroclinic Orbits for Singularly Perturbed Nearly Integrable Systems

Shangbing Ai, University of Pittsburgh

4:20-4:35 Heteroclinic Bifurcations as the Onset of Voltage Collapse in a Power System Model

Hinke Osinga, California Institute of Technology

4:40-4:55 Homoclinic and Heteroclinic Motions for Resonant Periodic Orbits in Forced, Two-Degree-of-Freedom Systems

Kazuyuki Yagasaki, Gifu University, Japan

Sunday, May 23

CP8

Materials

3:00 PM-4:40 PM

Room: Superior A

Chair: Michael Grinfeld, University of Strathclyde, Glasgow, Scotland

3:00-3:15 An Integrodifferential Model of Phase Separation
Dugald B. Duncan, Heriot-Watt University, Edinburgh, Scotland; *Michael Grinfeld* and Iulian Stoleriu, University of Strathclyde, Glasgow, Scotland

3:20-3:35 Propagation of Phase Transformation Front in 1D Shape Memory Allow Induced by Impact Loading
Alexander Bekker, Texas A&M University, College Station

3:40-3:55 Nucleation Dynamics of Cahn-Hilliard Equation
Junping Shi, Tulane University

4:00-4:15 Critical States and Minima for an Energy with Second Order Gradients
F. Dias, CNRS and Université de Nice – Sophia Antipolis, France; and J. M. Ghidaglia, Ecole Normale Supérieure de Cachan and CNRS, Cachan Cedex, France

4:20-4:35 Disjoining Potential and Spreading of Thin Liquid Layers in Diffuse Interface Model Coupled to Hydrodynamics
Len Pismen, Northwestern University; and Yves Pomeau, Ecole Normale Supérieure, France

Sunday, May 23

CP9

Bifurcations in Nonsmooth Systems

3:00 PM-4:00 PM

Room: Superior B

Chair: To be announced

3:00-3:15 Asymptotic Behavior in a Two Degree of Freedom Mechanical System with a Stop
Andre Xavier C. N. Valente, and Igor Mezic, University of California, Santa Barbara; and Harris McClamroch, University of Michigan, Ann Arbor

3:20-3:35 Dynamics and Control of a Constrained Impact Oscillator
Eugenio Gutierrez Tenreiro and Jose M. Zaldivar, Commission of the European Communities, Ispra, Italy

3:40-3:55 Intermittent Phase Transitions in a Two-Dimensional Stick-Slip Model of Earthquakes
Vladimir B. Ryabov, Kobe University, Japan

Sunday, May 23

Dinner

5:00 PM-7:00 PM

Attendees are on their own.

Monday, May 24

For papers with multiple authors, *the speaker is shown in italics,* if known at press time.

Monday, May 24

Registration Open

7:30 AM-4:00 PM

Location: Ballroom Lobby

Monday, May 24

IP3

Dynamics of Microstructure/ Flow Interactions

8:30 AM-9:30 AM

Room: Ballrooms I, II & III

Chair: Raymond Goldstein, University of Arizona

Many complex materials such as polymers and liquid crystal polymers are processed as "melts" in special geometries and flows, both for technological purposes (super-strength materials) and in natural biological functions (spiders spinning silk). Molecular-scale orientation interacts with the flow and any free surface effects, yielding remarkable phenomena which are difficult to explain. The speaker will describe constitutive laws for flows of rod-like molecules, and then apply the moment averaged equations of Doi and co-workers to probe two phenomena rich in dynamical systems flavor: microstructural suppression of the Rayleigh capillary instability, and the classical isotropic-to-nematic phase transition in the presence of an imposed flow.

M. Gregory Forest
Department of Mathematics, University of North Carolina, Chapel Hill

Monday, May 24

Coffee

9:30 AM-10:00 AM

Location: Ballroom Lobby

10:00 AM-12:00 PM
Concurrent Sessions

Monday, May 24

MS11

Chaos and Communication

10:00 AM-12:00 PM

Room: Ballroom I

The main issues to be addressed in this minisymposium are: optimal symbolic representation with judiciously chosen generating partitions, efficient message encoding, channel capacity, multiplexing, signal dropout reconstruction, and experimental results with erbium doped ring lasers in communication with chaotic optical systems. The basic common ground for all these issues is that chaotic signals can be controlled with very small perturbations which cause no significant change in the topological dynamics. Chaotic signals are naturally complex and provide a vehicle for information transmission that will often have technological advantages. Some of them will also be addressed in this minisymposium.

Organizers: Epaminondas Rosa, Jr.
University of Miami

Celso Grebogi
University of Maryland, College Park

10:00-10:25 Communicating with Chaos
Celso Grebogi, Organizer

10:30-10:55 Communicating with Chaos Using Two-Dimensional Symbolic Dynamics
Ying-Cheng Lai, University of Kansas

11:00-11:25 Redundant Chaotic Signals
Epaminondas Rosa, Jr., Organizer

11:30-11:55 Communication with Chaotic Waveforms
Rajarshi Roy, Georgia Institute of Technology

Monday, May 24

MS12

Applied Topology in Dynamics

10:00 AM-12:00 PM

Room: Ballroom II

Many ideas in dynamics are based on topology. This minisymposium will display a wide variety of interactions where the topology tells the scientist what behavior to expect. For example, the topology of Fermi surfaces determines the conductivity properties of "normal" metals in strong magnetic fields (Novikov). Similarly basic topological considerations determine the recurrence patterns in (non-convex) open billiards (Kennedy). The topological theory of Cartheodory, Cartwright, and Littlewood allows Alligood to describe sudden changes in the recurrent sets of the forced damped pendulum. For Barge the continuity of topology determines the discrete arrangements of tilings and quasicrystals.

Organizers: James A. Yorke and Serguei P. Novikov
University of Maryland, College Park

10:00-10:25 Topological Phenomena in the 3D Single Crystal Normal Metals
Serguei P. Novikov, Organizer

10:30-10:55 Topology of One-Dimensional Tilings
Marcy Barge, Montana State University, Bozeman

11:00-11:25 The Topology of Explosions: Sudden Appearance of Recurrent Points
Kathleen T. Alligood, George Mason University

11:30-11:55 Topological Horseshoes
Judy Kennedy, University of Delaware; James A. Yorke, Organizer; and Sahin Kocak, Anadolu University, Turkey

Monday, May 24

MS13

Dynamical Data Analysis in Biology

10:00 AM-12:00 PM

Room: Ballroom III

The speakers in this minisymposium will discuss current applications of time series analysis and control techniques in biological settings. The applications include the control of a cardiac arrhythmia; a dynamical characterization of tremor; the dynamics of a network of neurons in the mammalian hippocampus; and identifying saddle periodic points in noisy experimental time series.

Organizers: Eric Kostelich
Arizona State University

Timothy Sauer
George Mason University

10:00-10:25 Dynamic Control of Cardiac Alternans
Kevin Hall and Leon Glass, McGill University, Canada; David Christini and James J. Collins, Boston University; and Jacques Billette, Université de Montréal, Canada

10:30-10:55 Cross-Spectral Analysis of Tremor Time Series
Jens Timmer, Michael Lauk and C. H. Lücking, Universität Freiburg, Germany; and G. Deuschl, Universität Kiel, Germany

11:00-11:25 Using Control Blindly to Find Unstable Periodic Orbits
Daniel T. Kaplan, Macalester College

11:30-11:55 Shedding Light on Neuronal Dynamical "Dark Matter"
Steven J. Schiff, Joseph T. Francis, Bruce J. Gluckman, and Paul T. So, George Mason University

Monday, May 24

MS14

Characterization of Spatiotemporal Chaos

10:00 AM-12:30 PM

Room: Magpie A/B

Despite the identification of spatiotemporal chaos (STC) in many physical systems, e.g. lasers, fibrillating hearts, convecting fluids, and flame fronts, a theoretical understanding of STC remains elusive. Characterization of the STC state is an essential first step towards the development of a theory. The speakers in this minisymposium will focus on four directions for characterizing STC, including the development of order parameters that distinguish chaotic states, reduced wavelet descriptions of spatiotemporal chaotic partial differential equations, unstable periodic orbit analysis of high-dimensional attractors, and the control and perturbation of spatially extended systems.

Organizer: Scott M. Zoldi
Los Alamos National Laboratory

10:00-10:25 Controlling Turbulence by Global Feedbacks
Dorjsuren Battogtokh, Kyoto University, Japan; and *Alexander S. Mikhailov*, Fritz Haber Institute der MPG, Berlin, Germany

10:30-10:55 Characterizations of Natural Patterns
Gemunu H. Gunaratne, University of Houston

11:00-11:25 A Wavelet-Based Investigation of a Spatiotemporally Chaotic System
Ralf W. Wittenberg, University of Minnesota, Minneapolis; and Philip Holmes, Princeton University

11:30-11:55 Periodic Orbit Analysis of High Dimensional Spatiotemporal Chaos
Scott M. Zoldi, Organizer; and Henry S. Greenside, Duke University

12:00-12:25 Characterization and Control of Spatiotemporal Systems
Nita Parekh, Centre for Cellular and Molecular Biology, Hyderabad, India; V. Ravi Kumar and B. D. Kulkarni, National Chemical Laboratory, India

Monday, May 24

MS15

Nonlinear Dynamics of Partial Differential Evolution Equations and Applications

10:00 AM-12:00 PM

Room: Wasatch A/B

In the past decade, a great deal of progress was made in using dynamical systems and solitons to studying the dynamics of nonlinear partial differential equations. Many applications, such as nonlinear optics, furnish examples that exhibit both very regular and chaotic dynamics. There has, therefore, always existed a beneficial mutual interaction between these fields and various branches of dynamical systems, including, more recently, those pertaining to partial differential equations. The speakers in this minisymposium will illustrate this interaction by describing the dynamical behavior of specific partial differential equations that arise in nonlinear optics and other applied fields, and discussing several new techniques. These include dynamical systems analysis of homoclinic orbits and chaotic dynamics in partial differential equations, turbulence theory, kinetic equations, numerical computations and diagnostics for nonlinear partial differential equations, and perturbation theory for near-integrable partial differential equations and solitons. Applications will include semiconductor lasers, long ring-cavity gas lasers, and fiber optics. Analytical and numerical studies will be presented.

Organizer: Gregor Kovacic
Rensselaer Polytechnic Institute

10:00-10:25 Soliton Perturbations and the Random Kepler Problem
Jared C. Bronski, University of Illinois, Urbana-Champaign; Fatkhulla Kh. Abdullaev, Physical-Technical Institute, Uzbekistan; and G. Papanicolaou, Stanford University

10:30-10:55 Shilnikov Manifolds in Coupled Nonlinear Schrödinger Equations
George Haller, Brown University

11:00-11:25 Weak Turbulence with Applications to Semiconductor Lasers and Fiber Optics
Yuri Lvov, Los Alamos National Laboratory

11:30-11:55 Dynamics of Long Ring Lasers
Gregor Kovacic, Organizer; and Ilya Timofeyev, Courant Institute of Mathematical Sciences, New York University

Monday, May 24

MS16

Numerical Analysis of Contact Problems Involving Friction

10:00 AM-12:00 PM

Room: Golden Cliff

The objective of this minisymposium is to present current developments in the area of robust contact algorithms capable of dealing with multibody contact problems. The bodies may be rigid or elastic and some of the systems may involve friction and fragmentation. The minisymposium will feature the formulation and analysis of the proposed methods, as well as their numerical implementation. Some of the presentations will provide numerical simulations that illustrate the performance of the techniques.

Organizer: Couro Kane
California Institute of Technology

10:00-10:25 Variational Structure/ Numerics of Contact Problems
Couro Kane, Organizer; Jerrold E. Marsden and Michael Ortiz, California Institute of Technology

10:30-10:55 Numerical Analysis of Dynamic Contact/Impact in Elastic Multi-Body Systems
Francisco Armero, University of California, Berkeley

11:00-11:25 Symplectic-Energy-Momentum Integrators
Jerrold E. Marsden, California Institute of Technology; Couro Kane, Organizer; and Michael Ortiz, California Institute of Technology

11:30-11:55 Smooth Interpolations for Frictional Contact Problems
Peter Wriggers and Louvre Krostulovic-Opara, Universität Hannover, Germany

Monday, May 24

MS17

Analysis and Computation of Bistable Differential-Difference Equations

10:00 AM-12:00 PM

Room: Maybird

We focus on recent developments in the analysis and computation of bistable differential-difference equations, including reaction-diffusion and Cahn-Hilliard like equations. The problem areas include integrodifferential models for both spatially discrete and spatially continuous systems, a Fredholm theory for equations with backward and forward delays to analyze the structure of traveling wave solutions and that forms the basis for a numerical technique for the computation of traveling waves, and analysis and computational techniques for equilibrium solutions of spatially discrete Cahn-Hilliard equations. An important issue to be addressed is the relative impact of both spatially discrete and continuous terms on the dynamics.

Organizer: Erik S. Van Vleck
Colorado School of Mines

10:00-10:25 A Discrete Convolution Model for Phase Transitions
Peter Bates, Brigham Young University; and Adam Chmaj, Utah State University

10:30-10:55 A Variant of Newton's Method for the Computation of Traveling Wave Solutions of Differential-Difference Equations
Christopher Elmer, National Institute of Standards and Technology, Gaithersburg; and Erik S. Van Vleck, Organizer

11:00-11:25 Mosaic Solutions and Entropy for Spatially Discrete Cahn-Hilliard Equations
K. A. Abell and *Anthony R. Humphries*, University of Sussex, Brighton, United Kingdom; and Erik S. Van Vleck, Organizer

11:30-11:55 Crystallographic Pinning: Direction Dependent Traveling Waves in Higher Dimensional Lattices
John Mallet-Paret, Brown University

Monday, May 24

MS18

Nonlinear Evolution, Separatrix Splitting, and Chaos in Dynamical Systems

10:00 AM-12:00 PM

Room: Superior A

This minisymposium will focus on singular perturbation methods used in the analysis of the nonlinear behavior of complicated dynamical systems. These methods include, but are not limited to, reductive perturbative techniques and exponential asymptotics. The speakers will discuss the scope of the current formulations, including both avenues of further development, as well as limitations and possible alternative approaches, associated techniques for the identification and characterization of chaotic/turbulent solutions, and applications to nonlinear optics, astrophysical and space plasmas, classical dynamics, and general relativity.

Organizer: S. Roy Choudhury
University of Central Florida

10:00-10:25 Onset of Chaos in Singularly Perturbed Systems
Alexander Tovbis, University of Central Florida

10:30-10:55 Nonlinear Evolution and Chaos in the Kelvin-Helmholtz Instability of High Velocity Anisotropic Shear Layers
Kevin G. Brown, University of Central Florida, and *S. Roy Choudhury*, Organizer

11:00-11:25 Speaker and title to be announced

11:30-11:55 Speaker and title to be announced

Monday, May 24

MS19

Flows of Liquid Crystalline Polymers

10:00 AM-12:00 PM

Room: Superior B

Liquid crystalline polymer (LCP) materials have been widely used in industrial and military applications. Modeling of the complex flows and characterization of the materials needs an effort across multiple disciplines ranging from model building to large-scale computation and analysis of complex dynamics. The participants in this minisymposium will present new molecular models for semi-flexible LCPs, a new continuum mechanical theory for nematic elastomers, kinetic theory for LCPs, analytical and numerical analysis on phase transitions in liquid crystal materials, modeling and computation of complex flows and formation of textures and defects in LCP flows. The study of LCP flows has come to the point where sophisticated computational and dynamical system tools are indispensable. The purpose of the minisymposium is therefore to enhance interactions among the active researchers.

Organizer: Qi Wang
Indiana University, Purdue University

10:00-10:25 Direct Numerical Simulation of Nematic Textures: Phase Transitions and Shearing Flows
Alejandro D. Rey, McGill University, Montréal, Canada

10:30-10:55 Modeling of the Smectic A - Nematic Phase Transition
M. Carme Calderer, Pennsylvania State University

11:00-11:25 Kinetic Models of Polymer-Lliquid Crystal Systems
Weinan E and *Cyrill Muratov*, Courant Institute of Mathematical Sciences, New York University

11:30-11:55 Viscoelasticity of Solutions of Semi-Flexible Polymers
David Morse, University of Minnesota, Minneapolis

Monday, May 24

MS20

Stability and Bifurcations of Relative Equilibria: Theory

10:00 AM-12:00 PM

Room: White Pine

Relative equilibria are trajectories of dynamical systems which are stationary modulo a group action. They include steady rotations of physical systems about fixed axes without changes of 'shape' and are of considerable interest in areas as diverse as N-body problems in celestial mechanics, molecules, systems of point vortices, multibody mechanics and rotating fluid masses. Some of these applications will feature in other (proposed) minisymposia at this conference. This session will be devoted to recent theoretical developments which improve our understanding of the stability properties and bifurcations of relative equilibria and underpin new computational techniques for applications.

Organizers: Mark Roberts
University of Warwick, Coventry, United Kingdom

James Montaldi
Université de Nice, Valbonne, France

10:00-10:25 Stabilizing and Destabilizing Effects of Dissipation on Manifolds of Relative Equilibria
Gianne Derks, University of Surrey, United Kingdom

10:30-10:55 Mechanics on Homogenous Spaces
Andrew Lewis, Queen's University, Kingston, Canada

11:00-11:25 On Relative Normal Modes
Eugene Lerman and T. Tokieda, University of Illinois, Urbana-Champaign

11:30-11:55 Bifurcations from Symmetric Relative Equilibria
Debra Lewis, University of California, Santa Cruz

Monday, May 24

Lunch

12:00 PM-1:30 PM

Attendees are on their own.

Monday, May 24

IP4

Life at the Boundary of Chaos Theory and Nonequilibrium Statistical Mechanics

1:30 PM-2:30 PM

Room: Ballrooms I, II & III

Chair: Mary Silber, Northwestern University

The last decade or so has seen a strong surge of interest in the applications of dynamical systems theory to problems of interest to workers in nonequilibrium statistical mechanics. Unexpected relations have been discovered between transport coefficients, which appear in the macroscopic equations of fluid dynamics, and the Lyapunov exponents, Kolmogorov-Sinai entropies, and other quantities which characterize chaotic processes in the underlying microscopic dynamics. Stimulated by these relations, workers have developed methods to compute dynamical quantities, based on familiar techniques in statistical mechanics. The speakers will discuss these results and some important new theorems, such as the Gallavotti-Cohen fluctuation theorem, and the conjugate pairing rule for Lyapunov exponents. He will also mention some very interesting issues relating to the applications of SRB and related measures to entropy production and Green-Kubo formulae for transport coefficients.

J. Robert Dorfman
Institute for Physical Science and Technology University of Maryland, College Park

Monday, May 24

Coffee

2:30 PM-3:00 PM

Location: Ballroom Lobby

3:00 PM-5:00 PM
Concurrent Sessions

Monday, May 24

MS21

Embeddings and Control — Part I of II

3:00 PM-5:00 PM

Room: Ballroom I

For Part II, see MS26

For many experimental setups, no mathematical model is available. Embedding Techniques (introduced by Ruelle and Takens and made dynamic by Eckmann-Ruelle and Sano-Sawada) allow the reconstruction of the attractor numerically from the data. But these techniques are only the beginning. The problem is how can we create more reliable, more useful reconstructions. Can we compute Lyapunov exponents reliably? How many? Given a reconstruction (and no model), can (small) feedback controls be used to control the dynamics of the experiment? The idea is to select unstable trajectories of the system and use feedback control to stabilize these orbits.

Organizer: James A. Yorke
University of Maryland, College Park

3:00-3:25 Visualization, Identification and Control of Chaos in Biological Systems
William L. Ditto, Georgia Institute of Technology

3:30-3:55 Nonlinear Prediction, Filtering and Control of Chemical Systems from Time Series
Kenneth Showalter and Valery Petrov, West Virginia University

4:00-4:25 Influence of Noise on Control of Chaotic Lasers
Rajarshi Roy, Georgia Institute of Technology

4:30-4:55 Controlling and Synchronizing Space Time Chaos
Stefano Boccaletti, University of Navarra, Pamplona, Spain; F. Tito Arecchi and Jean Bragard, Istituto Nazionale di Ottica, Florence, Italy

Monday, May 24

MS22

Networks of Oscillators

3:00 PM-5:00 PM

Room: Ballroom II

Networks of nonlinear oscillators arise in many branches of science and engineering. They also pose fascinating mathematical problems that link dynamical systems theory to statistical mechanics, graph theory, and distributed computation. This minisymposium surveys recent developments in oscillator networks. The topics run the gamut from traditional with a twist (new bifurcation scenario in injection-locked lasers), to cutting-edge contemporary (phase locking and signal encoding in neural nets), to offbeat (why "six degrees of separation" may be much more than a curiosity of social networks).

Organizers: Steven H. Strogatz
Cornell University

Paul C. Bressloff
Loughborough University, United Kingdom

3:00-3:25 Synchronization of Pulse-Coupled Oscillators with Delays
Paul C. Bressloff, Organizer

3:30-3:55 Population Coding and Noise Shaping in Spiking Neurons
Carson C. Chow, University of Pittsburgh

4:00-4:25 Dynamics of a Solid-State Laser with Injection
Steven H. Strogatz, Organizer

4:30-4:55 Small Worlds: The Dynamics of Networks Between Order and Randomness
Duncan J Watts, The Santa Fe Institute

Monday, May 24

MS23

Mathematical and Computational Issues in Dynamics and Turbulence

3:00 PM-5:00 PM

Room: Ballroom III

The mathematics of rotating and stratified flows, particularly the reduced systems that emerge from asymptotic analyses, have played an important role in developing useful conceptual frameworks, especially in theoretical and numerical calculations. The minisymposium will aim to establish rigorous results on the dynamics of such flows and focus attention on problems that require careful mathematical analysis and numerical algorithms. The speakers in this session will focus on theoretical issues.

Organizers: Basil Nicolaenko and Alex Mahalov
Arizona State University

3:00-3:25 Geometric Approximation Methods in Ocean Modeling
Darryl D. Holm, Los Alamos National Laboratory

3:30-3:55 On the Algebra of the Curl Operator for Euler and Navier-Stokes Equations
Ciprian Foias, Indiana University, Bloomington

4:00-4:25 Fast Singular Oscillating Limits of Stably Stratified Three-Dimensional Euler-Boussinesq Equations
Anatoli Babin, University California, Irvine; Alex Mahalov and Basil Nicolaenko, Organizers

4:30-4:55 Monge-Ampére Equations in Balanced Models
Ian Roulstone, United Kingdom Meteorological Office, Berkshire, United Kingdom

Monday, May 24

MS24

Qualitative Analysis of Nonlinear Partial Differential Equations

3:00 PM-5:00 PM

Room: Superior A

The qualitative theory of nonlinear PDEs has developed considerably over the last few years. The dynamical systems theory of dissipative nonlinear PDEs allow one to solve problems where the dynamics settle to a low-dimensional set of solutions and to control these dynamics. Problems where the dynamics remain high-dimensional offer more challenge, but the elements of a high-dimensional dynamical system theory for nonlinear PDEs are beginning to emerge. In this session, the speakers will explore these emerging techniques and their application.

Organizer: Björn Birnir
University of California, Santa Barbara

3:00-3:25 Emergence of Channelized Drainage Patterns and Landsurface Scalings
Terence R. Smith, University of California, Santa Barbara; Björn Birnir, Organizer; and George E. Merchant, University of California, Santa Barbara

3:30-3:55 Well-Posedness and Ill-Posedness for the Initial Value Problem of Nonlinear Dispersive Equations
Gustavo Ponce, University of California, Santa Barbara; Carlos E. Kenig, University of Chicago; and Luis Vega, Universidad del Pais Vasco, Bilbao, España

4:00-4:25 The Evolution of Compactly Supported Planar Vorticity
Thomas C. Sideris, University of California, Santa Barbara; and Dragos Iftimie, Université de Rennes 1, France

4:30-4:55 Speaker and title to be announced

Monday, May 24

MS25

Chaos and Irreversibility

3:00 PM-5:00 PM

Room: Maybird

This minisymposium aims at augmenting the plenary talk by J. Robert Dorfinan on the relation between transport properties of many-particle systems and their underlying chaotic dynamics. The speakers in this minisymposium will discuss the possibility of experimentally observing chaos in many article systems, and the modelling of thermodynamic transport properties by spatially extended chaotic maps of the plane. Special attention is devoted to entropy production fluctuations in nonequilibrium steady states, and to recent results of computer simulations of many-particle systems and turbulence.

Organizer: Tamás Tél
Eötvös University, Budapest, Hungary

3:00-3:25 Probing the Microcospic Chaos of a Fluid of Particles with a Brownian Test Particle
Pierre Gaspard, Université Libre de Bruxelles, Belgium

3:30-3:55 Time Reversibility, Entropy Balance, and the Green-Kubo Relations
Jürgen Vollmer, Universität GH Essen, Germany

4:00-4:25 Multifractal Phase Space Densities for Stationary Nonequilibrium Systems
Harald A. Posch, Universität Wien, Austria

4:30-4:55 Hyperbolicity and KAM Bottles in the Driven Lorentz Gas
Maciej Wojtkowski, University of Arizona

Monday, May 24

CP10

Geophysical Flows

3:00 PM-5:00 PM

Room: Magpie A/B

Chair: Ferdinand Verhulst, University of Utrecht, The Netherlands

3:00-3:15 A Low-Dimensional Climate Model I
Ferdinand Verhulst, University of Utrecht, The Netherlands

3:20-3:35 A Low Dimensional Climate Model II
Lennaert van Veen, University of Utrecht, The Netherlands

3:40-3:55 Global Bifurcation in a Simple Ocean Model
B. T. Nadiga and Benjamin Luce, Los Alamos National Laboratory

4:00-4:15 Low-Dimensional Atmospheric Models at Various Truncations
Daan Crommelin, Royal Netherlands Meteorological Institute, The Netherlands

4:20-4:35 Finite Difference Balanced Models
Don Jones, Arizona State University

4:40-4:55 Reversals and on-off Intermittency in the Dynamics of the Convective Dynamo
Iuliana Oprea, University of Bucharest, Romania and Arizona State University

Monday, May 24

CP11

Granular Flows

3:00 PM-4:20 PM

Room: Wasatch A/B

Chair: Troy Shinbrot, Rutgers University

3:00-3:15 Spontaneous Chaotic Granular Mixing
Troy Shinbrot, Albert W. Alexander, and Fernando J. Muzzio, Rutgers University

3:20-3:35 About Motion of Spherical Particles on a Surface
Ljubinko (Lou) Kondic, Meenakshi Dutt, and Robert P. Behringer, Duke University

3:40-3:55 Molecular Dynamic Simulations of Clusters in Sheared Granular Materials
Elizabeth D. Liss and Benjamin J. Glasser, Rutgers University

4:00-4:15 A Kinetic Model for Granular Media
Xinzhong Chen and Edward A. Spiegel, Columbia University

Monday, May 24

CP12

Physiology

3:00 PM-5:00 PM

Room: Superior B

Chair: James Lawry, California Academy of Sciences, San Francisco

3:00-3:15 Respiration by Turbulant Diffusion in Frogs

James Lawry, California Academy of Sciences, San Francisco

3:20-3:35 Modelling the Control of Ovulation in Terms of Gonadotropin Receptors in Granulosa Cells

A. Chavez-Ross and J. Stark, University College London, United Kingdom; and S. Franks, Imperial College of Science Technology and Medicine, London, United Kingdom

3:40-3:55 Subcellular Mechanisms for the Regularization of Neural Bursting Activity

Pablo Varona, Joaquin J. Torres, Ramon Huerta, Henry D. I. Abarbanel and Mikhail I. Rabinovich, University of California, San Diego

4:00-4:15 The Mechanics of Lung Tissue Under High-Frequency Lung Ventilation

Markus R. Owen, Mark A. Lewis, and David J. Eyre, University of Utah

4:20-4:35 Cardiorespiratory Interaction in Anesthesia

Aneta Stefanovska and Mario Hozic, University of Ljubljana, Slovenia; and Hermann Haken, Universität Stuttgart, Germany

4:40-4:55 Dynamics of Human Blood Distribution System

Maja Bracic and Aneta Stefanovska, University of Ljubljana, Slovenia

Monday, May 24

CP13

Delay Equations

3:00 PM-4:40 PM

Room: Golden Cliff

Chair: Thomas Erneux, Universiteit Libre de Bruxelles, Belgium

3:00-3:15 Delay-Differential Equations with a Large Delay: Application to Semiconductor Laser Instabilities

Didier Pieroux and *Thomas Erneux,* Universiteit Libre de Bruxelles, Belgium

3:20-3:35 The Constraction of the Asymptotic Solutions of the System of Differential Equations with Deviating Argument

Vladimir Domnytsky, Montréal, Canada

3:40-3:55 On the Stability of Neutral Functional Differential Equations

Wim Michiels, Dirk Roose, and Koen Engelborghs, Catholique Universiteit Leuven, Belgium

4:00-4:15 Numerical Methods for Delay Differential Equations: New Approach, Software Package, Applications

Arkadii V. Kim, Seoul National University, Korea; Oh Bok Kwon, Kyung Bok College, Kyung-Kido, Seoul, Korea; Vladimir G. Pimenov, Ural State University, Ekaterinburg, Russia

4:20-4:35 Existence of Periodic Solutions for a State Dependent Delay Differential Equation

P. Magal, Faculte des Sciences et Techniques, Le Havre, France; and O. Arino, Université de Pau, France

Monday, May 24

CP14

Hamiltonian Systems

3:00 PM-5:00 PM

Room: White Pine

Chair: James D. Meiss, University of Colorado, Boulder

3:00-3:15 Quadratic Volume Preserving Maps: Normal Forms and Dynamics

James D. Meiss, University of Colorado, Boulder; and Hector E. Lomeli, Instituto Tecnologico Autonomo de México

3:20-3:35 Size Matters in Small One-Dimensional Lattices

Chih-Yu Lin and Seth Lichter, Northwestern University; Sung N. Cho and *Christopher G. Goedde,* DePaul University

3:40-3:55 Stability Exponents and Separation of Variables

William E. Wiesel, Air Force Institute of Technology/ENY

4:00-4:15 Vanishing Twist Near Resonances in Symplectic Maps

Holger R. Dullin, David G. Sterling, and James D. Meiss, University of Colorado, Boulder

4:20-4:35 Volume-Preserving Reduction by Symmetry

Nathan Frazier and Igor Mezic, University of California, Santa Barbara

4:40-4:55 Properties of Integrability of Systems in Terms of Transcendental Functions

Maxim V. Shamolin, Lomonosov Moscow State University, Russia

Monday, May 24

Business Meeting

SIAM Activity Group on Dynamical Systems (SIAG/DS)

5:00 PM-6:00 PM

Room: Ballroom I

Chair: Shui-Nee Chow, Georgia Institute of Technology, and National University of Singapore

Monday, May 24

Dinner

6:00 PM

Attendees are on their own.

Tuesday, May 25

For papers with multiple authors, *the speaker is shown in italics,* if known at press time.

Tuesday, May 25

Registration Open

7:30 AM-4:00 PM

Location: Ballroom Lobby

Tuesday, May 25

IP5

Attractors in Evolutionary Equations

8:30 AM-9:30 AM

Room: Ballrooms I, II & III

Chair: Peter Bates, Brigham Young University

The speaker will discuss conditions for the existence of compact global attractors. He will present specific examples for which there is much known about the flow on the attractor, and will emphasize parabolic and hyperbolic PDEs.

Jack Hale
School of Mathematics, Georgia Institute of Technology

Tuesday, May 25

Coffee

9:30 AM-10:00 AM

Location: Ballroom Lobby

10:00 AM-12:00 PM
Concurrent Sessions

Tuesday, May 25

MS26

Embeddings and Control — Part II of II

10:00 AM-12:00 PM

Room: Ballroom I

For Part I, see MS21

For many experimental setups, no mathematical model is available. Embedding Techniques (introduced by Ruelle and Takens and made dynamic by Eckmann-Ruelle and Sano-Sawada) allow the reconstruction of the attractor numerically from the data. But these techniques are only the beginning. The problem is how can we create more reliable, more useful reconstructions. Can we compute Lyapunov exponents reliably? How many? Given a reconstruction (and no model), can (small) feedback controls be used to control the dynamics of the experiment? The idea is to select unstable trajectories of the system and use feedback control to stabilize these orbits.

Organizer: James A. Yorke
University of Maryland, College Park

10:00-10:25 Embeddings, Fractals and Making Sense of Digital Communications
David S. Broomhead, J. P. Huke, and Mark R. Muldoon, University of Manchester Institute of Science and Technology, United Kingdom

10:30-10:55 Spurious Lyapunov Exponents in Attractor Reconstruction
Timothy D. Sauer, George Mason University

11:00-11:25 When Embeddings Perfectly Reflect the Dynamics
James A. Yorke, Organizer; Josh Tempkin, University of Maryland, College Park; and Timothy D. Sauer, George Mason University

11:30-11:55 Projections, Embedding, and Fractal Dimensions
Brian Hunt, University of Maryland, College Park; and Vadim Yu. Kaloshin, Princeton University

Tuesday, May 25

MS27

Vibrating Granular Media

10:00 AM-12:00 PM

Room: Ballroom II

Granular media are systems of macroscopic particles that interact mainly through contact forces. Granular media abound in nature and industry, but are not well understood. Recent laboratory experiments on granular media in oscillated containers have revealed a variety of collective phenomena—heaping, segregation, compaction, convection, spatial patterns, and clustering. The speakers in this minisymposium will describe the phenomena and molecular dynamics simulations developed to understand them. The simulations assume that the particles obey Newton's laws and that energy is dissipated in collisions. While simulations and pde models provide many open questions.

Organizer: Harry L. Swinney
University of Texas, Austin

10:00-10:25 Energy Flows, Segregation, and Collapse in Vibrated Granular Media
Stefan Luding, University of Stuttgart, Germany

10:30-10:55 Compaction and Thermodynamics in Vibrated Granular Media
Sidney R. Nagel, University of Chicago, Illinois

11:00-11:25 Stability and Dynamics of Vertically and Horizontally Shaken Sand
Robert P. Behringer, L. Kondic, S. Tennakoon, and R. Hartley, Duke University

11:30-11:55 Wave Patterns in Vertically Oscillated Granular Media
Chris Bizon, University of Texas, Austin

Tuesday, May 25

MS28

Nonlinear Advection Diffusion Equations: Analysis and Applications

10:00 AM-12:00 PM

Room: Ballroom III

The fundamental equations of fluid dynamics present some profound challenges. Extracting rigorous predictions with physical relevance from the equations of motion is a difficult task, but substantial progress has been achieved in recent years. The speakers in this minisymposium will focus on recent mathematical results for the incompressible Navier-Stokes and related equations and their relation to experiments and applications.

Organizers: Charles R. Doering
University of Michigan, Ann Arbor

Peter Constantin
University of Chicago, Illinois

10:00-10:25 Energy Dissipation Rate in Shear Driven Turbulence
Xiaoming Wang, Iowa State University

10:30-10:55 Dynamics and Blow Up for An Active Scalar
Michael P. Brenner, Massachusetts Institute of Technology; Peter Constantin, Organizer; Leo P. Kadanoff, Alain Schenkel, and *Shankar C. Venkataramani,* University of Chicago, Illinois

11:00-11:25 Scaling and Burning Velocity in Turbulent Combustion
Peter Constantin, Organizer; *Alexander Kiselev,* and Leonid Ryzhik, University of Chicago, Illinois

11:30-11:55 Towards a Variational Principle for the Navier-Stokes Equations
Richard R. Kerswell, Bristol University, United Kingdom

Tuesday, May 25

MS29

Bifurcations in Neuron Dynamics

10:00 AM-12:00 PM

Room: Magpie A/B

Neural excitability, spiking, and bursting result from certain bifurcations of the membrane potential of the cell. Revealing these bifurcations in mathematical models and in vivo helps to understand and classify dynamical properties of neurons and their networks. The speakers in this minisymposium will discuss recent work on neurons and neuron network models.

Organizer: Eugene M. Izhikevich
Arizona State University

10:00-10:25 Adaptation and Synchrony in Neural Oscillators
G. Bard Ermentrout, University of Pittsburgh

10:30-10:55 Phantom Bursting in Pancreatic Beta Cells
Richard Bertram and Joseph Previte, Pennsylvania State University; and Arthur Sherman, National Institutes of Health

11:00-11:25 Propagating Activity Patterns in Thalamic Networks
David Terman, Ohio State University

11:30-11:55 Neural Excitability, Spiking, and Bursting
Eugene M. Izhikevich, Organizer

Tuesday, May 25

MS30

Invariant Manifolds, Foliations and Applications

10:00 AM-12:00 PM

Room: Wasatch A/B

Invariant manifolds and foliations have become fundamental tools to study the qualitative properties of a flow or semiflow near invariant sets. They are extremely useful tracking the asymptotic behavior of solutions and providing coordinates in which systems of differential equations may be decoupled and normal forms derived. In many cases, they are useful for technical estimates which facilitate the study of bifurcation. In this minisymposium, the speakers will discuss a construction of periodic orbits for singularly perturbed systems, the existence of homoclinic orbits for singularly perturbed nonlinear Schrödinger equation, the existence and metastability of spiky solutions for reaction-diffusion systems with strong coupling, the motion of interacting spikes, and surface nucleation for the Ginzburg-Landau equations.

Organizer: Kening Lu
Brigham Young University

10:00-10:25 Periodic Orbits in Singularly Perturbed Systems
Christopher K.R.T. Jones, Brown University

10:30-10:55 Surface Nucleation of Superconductivity
Xingbin Pan, Zhejiang University, Hangzhou, People's Republic of China; and Kening Lu, Organizer

11:00-11:25 On Reaction-Diffusion Systems with Strong Coupling
Juncheng Wei, The Chinese University of Hong Kong, Hong Kong, People's Republic of China

11:30-11:55 Homoclinic Orbits for Singularly Perturbed NLS
Chongchun Zeng, Courant Institute of Mathematical Sciences, New York University

Tuesday, May 25

MS31

Nonlinear Dynamics in Communication: Coding, Channel Modeling and Secure Communications

10:00 AM-12:00 PM

Room: Golden Cliff

A quick glance at the literature might suggest that the tools of modern nonlinear dynamics have only a few significant applications to communications, chiefly the Pecora-Carroll protocols for secure communication via chaotic synchronization. The speakers in this symposium will touch on synchronization, but will also explore a wider range of applications. They will discuss the use of dynamical systems to generate novel codes, the interplay between nonlinear time series analysis and cryptographic assault, and the self-similar structure of telephone traffic.

Organizer: Mark R. Muldoon
University of Manchester Institute of Science and Technology, United Kingdom

10:00-10:25 Codes for Spread Spectrum Applications Generated With Chaotic Dynamical Systems
Mark R. Muldoon, Organizer; J. P. Huke and David S. Broomhead, University of Manchester Institute of Science and Technology, United Kingdom

10:30-10:55 Chaos, Communications and Nonlinear Data Analysis
Ulrich Parlitz and Jochen Bröcker, Universität Göttingen, Germany

11:00-11:25 Improving the Robustness of Synchronized Chaotic Communication Systems
Chris Williams, Defence Evaluation Research Agency, Malvern, United Kingdom

11:30-11:55 Levy-Stable Distributions and Self-Similar Teletraffic Modeling
Stephen McLaughlin, University of Edinburgh, United Kingdom

Tuesday, May 25

MS32

Observation, Analysis and Modeling of Excitable Systems

10:00 AM-12:00 PM

Room: Maybird

Various natural systems present excitable dynamical behavior, with excitability defined in terms of the systems response to perturbations. Such behavior can be found in biological systems, laser physics, and chemical reactions, among others. The combination of excitability with other dynamical processes gives rise to very particular behaviors. Diffusively coupled excitable systems generate some easily recognizable patterns. When subject to noise, excitable systems display a particular statistical behavior. In this minisymposium, the speakers will discuss the observation, analysis and modeling of different aspects of excitable systems with the aim of finding their underlying common features.

Organizers: Silvina Ponce Dawson and Gabriel B. Mindlin
Ciudad Universitaria, Buenos Aires, Argentina

10:00-10:25 Excitable Behavior in Semiconductor Lasers
Jorge L. Tredicce and M. Giudici, Université de Nice, Valbonne, France

10:30-10:55 Frequency Locked Patterns in a Periodically Perturbed Reaction-Diffusion System
Anna L. Lin, Valery Petrov, Alexandre Ardelea, Graham F. Carey, and Harry L. Swinney, University of Texas, Austin

11:00-11:25 Topological Structure of Noise Driven Excitable Systems
Gabriel B. Mindlin, Organizer; Manuel C. Eguia and Alejandro Yacomotti, Ciudad Universitaria, Buenos Aires, Argentina

11:30-11:55 Classifying Excitable Reaction-Diffusion Systems
Silvina Ponce Dawson, Organizer; and John E. Pearson, Los Alamos National Laboratory

Tuesday, May 25

MS33

Patten Formation in the Cahn-Hilliard Model — Part I of II

10:00AM-12:00 PM

Room: Superior A

For Part II, see CP37

In the forty years since its introduction, the Cahn-Hilliard model has proved its ability to exhibit pattern formation and phase separation phenomena like those being observed in binary metallic alloys. Therefore, understanding the dynamical behavior of the model is of immediate interest in materials sciences. While existing mathematical results for the one-dimensional model provide a fairly complete picture of its rich dynamics, most of the current research focuses on the physically more relevant two- and three-dimensional models, as well as their discrete and multi-component counterparts. The talks in the minisymposium will cover a broad spectrum of these recent studies.

Organizers: Stanislaus Maier-Paape
Georgia Institute of Technology

Thomas Wanner
University of Maryland, Baltimore County

10:00-10:25 The Motion of the Bubble Towards the Boundary
Nicholas Alikakos, University of Tennessee, Knoxville

10:30-10:55 Multi-Spike Solutions to the Cahn-Hilliard Equation
Peter Bates, Brigham Young University; and Giorgio Fusco, Universitá di L'Aquila, Italy

11:00-11:25 Cascades of Instability in the Solutions of Vector-Valued Cahn-Hilliard Equations
David J. Eyre, University of Utah

11:30-11:55 Pattern Formation in Gradient Systems
Paul Fife, University of Utah; and Michal Kowalczyk, Carnegie-Mellon University

Tuesday, May 25

MS34

New Models and Analysis of Noise-Sensitive Dynamical Systems

10:00 AM-12:00 PM

Room: Superior B

This minisymposium addresses modeling of stochastic effects in applied problems and methods, such as statistical analysis, projection techniques, and asymptotic expansions, used to investigate these models. Systems with diffusion and jump noises are modeled with stochastic ordinary and partial differential equations. Probability densities describing the dynamics of noisy metastable interfaces are obtained from new models. Stochastic resonance in excitable systems, such as neuron firing, are measured with new tools. Diffusion in a randomly fluctuating potential can be controlled to optimize a nonzero steady-state current. Discrete and continuous models of boundary effects in random transport are examined for ionic channels.

Organizers: Rachel Kuske
University of Minnesota, Minneapolis

Malgorzata M. Klosek
University of Wisconsin, Milwaukee

10:00-10:25 A Combined Molecular Dynamics and Diffusion Model for Single Proton Conduction Through Gramicidins
Mark F. Schumaker, Washington State University

10:30-10:55 Stochastic Resonance and Neuron Firing: Statistical Aspects
Priscilla Greenwood, University of British Columbia, Vancouver, Canada

11:00-11:25 Current in Sharp Additive Ratchets: Analysis and Exact Results
Malgorzata M. Klosek, Organizer

11:30-11:55 Models and Prediction for Noisy Interface Dynamics
Rachel Kuske, Organizer; and Michael Ward, University of British Columbia, Vancouver, Canada

Tuesday, May 25

MS35

Stability and Bifurcations of Relative Equilibria: Applications

10:00 AM-12:00 PM

Room: White Pine

Relative equilibria arise in nature and in industry. For example, steady rotation of coupled rigid or deformable bodies and steady motions in fluid models are of interest to engineers, physicists, and chemists. The analysis of concrete examples elucidates the limitations of existing theoretical approaches and can bring to light unrecognized structures, leading to more general or efficient methodologies. The speakers in this minisymposium will focus on several specific applications and demonstrate mutually beneficial interaction between theory and example.

Organizer: Debra K. Lewis
University of California, Santa Cruz

10:00-10:25 Nekhoroshev-Stability of Elliptic (Relative) Equilibria and the Riemann Ellipsoids
Francesco Fasso, Universitá di Padova, Italy

10:30-10:55 Stabilization of Relative Equilibria
Jerrold E. Marsden, California Institute of Technology

11:00-11:25 Drift of Certain 4-Vortex Relative Equilibria
George W. Patrick, University of Saskatchewan, Saskatoon, Canada

11:30-11:55 A Generalization of Riemann's Theorem for Rotating Fluid Masses
Mark Roberts, University of Warwick, United Kingdom

Tuesday, May 25

Lunch

12:00 PM-1:30 PM

Attendees are on their own.

Tuesday, May 25

IP6

Finite Element Analysis of Nonsmooth Contact

1:30 PM-2:30 PM

Room: Ballrooms I, II & III

Chair: Jerrold Marsden, California Institute of Technology

The objective of this presentation is to describe the development of robust contact algorithms capable of dealing with multibody nonsmooth contact geometries for which neither normals nor gap functions can be defined. These algorithms have many applications, for example to granular flows and to brittle solids undergoing fragmentation. Dynamic fragmentation often results in the formation of large numbers of fragments which undergo complex collision sequences before they eventually scatter. A robust and systematic procedure is therefore required in order to ascertain the precise sequence of collisions undergone by the bodies. The speaker will refer to contact processes such as described, involving the simultaneous interaction between many angular bodies, as nonsmooth contact. A suitable mathematical framework for dealing with this class of problems is furnished by nonsmooth analysis. However, it should be noted that the admissible sets which arise in contact problems are generally nonconvex, which precludes the direct application of convex analysis. The speaker will discuss some algorithms in simulations of fracture and fragmentation, and demonstrate their good performance.

Michael Ortiz
Graduate Aeronautical Laboratories
California Institute of Technology

Tuesday, May 25

Coffee

2:30 PM-3:00 PM

Location: Ballroom Lobby

3:00 PM-5:00 PM
Concurrent Sessions

Tuesday, May 25

CP15

Data Analysis I/ Spatiotemporal

3:00 PM-5:00 PM

Room: Ballroom I

Chair: Thomas Schreiber, University of Wuppertal, Germany

3:00-3:15 Locating Information Sources in Spatiotemporal Data
Thomas Schreiber, University of Wuppertal, Germany; and *Jochen Arnhold*, John von Neumann Institute for Computing (NIC), Forschungszentrum Jülich, Germany

3:20-3:35 Identification and Characterization of High-Dimensional Chaos
Martin J. Bünner and Antonio Politi, Istituto Nazionale di Ottica, Florence, Italy; Rainer Hegger and Holger Kantz, Max-Planck Institut für Physik Komplexer Systeme, Dresden, Germany

3:40-3:55 Lyapunov Spectra from Sub-System Information in Spatiotemporal Systems: A Time-Series Perspective
R. Carretero-Gonzalez, S. Orstavik and J. Stark, University College London, United Kingdom; J. Huke and D.S. Broomhead, University of Manchester Institute of Science and Technology, United Kingdom

4:00-4:15 Low-Dimensional Approximations to High-Dimensional Systems
Stephen P. Meacham, Atmospheric and Environmental Research Inc.

4:20-4:35 Spatiotemporal Chaos in Yttrium Iron Garnet Films
Christopher L. Goodridge, Frederic Rachford, Thomas Carroll and Louis Pecora, U.S. Naval Research Laboratory

4:40-4:55 Deterministic Structure in Data from a Free Running Neuronal Ensemble: A Comparison of Nonlinear Tests for Determinism
Joseph T. Francis, George Mason University and George Washington University; and Paul So, George Mason University

Tuesday, May 25

CP16

Mathematical Biology I

3:00 PM-5:00 PM

Room: Ballroom II

Chair: James F. Selgrade, North Carolina State University

3:00-3:15 Dynamical Behavior of a Discrete, Migration Model with Density-Dependent Selection
James F. Selgrade, North Carolina State University

3:20-3:35 Urn Models, Replicator Equations and Genetic Drift
Sebastian J. Schreiber, Western Washington University

3:40-3:55 Nonlinear Stability of Age-dependent Population Dynamics
C. B. Clemons, S. I. Hariharan and D. D. Quinn, The University of Akron

4:00-4:15 Complex Co-evolutionary Dynamics in Simple Ecological Foodwebs
James W. Haefner, Utah State University

4:20-4:35 Period-Doubling Bifurcation Leading to Chaos in an Ecological Model
A. Aziz Alaoui, Université Le Havre, France

4:40-4:55 Persistence and Extinction in Two Species Reaction-Diffusion Systems with Delays
Shigui Ruan, Dalhousie University; and Xiao-Qiang Zhao, Academia Sinica, China

Tuesday, May 25

CP17

Coupled Oscillators I

3:00 PM-5:00 PM

Room: Ballroom III

Chair: William F. Langford, University of Guelph, Canada

3:00-3:15 Coupled Oscillators Near Strong Resonances
William F. Langford, University of Guelph, Canada

3:20-3:35 From Mode-Locking to Chaos in Integrate-and-Fire Dynamical Systems
Stephen Coombes and Paul C. Bressloff, Loughborough University, Leicestershire, United Kingdom

3:40-3:55 Effect of Noise on Phase Synchronization of Coupled Chaotic Oscillators
Victor Andrade and Ying-Cheng Lai, University of Kansas, Lawrence

4:00-4:15 Observability of Lag Synchronization of Coupled Chaotic Oscillators
Saeed Taherion and Ying-Cheng Lai, University of Kansas, Lawrence

4:20-4:35 Extreme Parametric Uncertainty and Instant Chaos and in Coupled Structural Dynamics
Ira B. Schwartz, Yvette K. Wood and Ioannis T. Georgiou, U.S. Naval Research Laboratory

4:40-4:55 Chaotic Oscillations in the Duffing Oscillator with High- and Low-Frequency External Forcing
Dmytro V. Shygimaga and Dmytro M. Vavriv, Institute of Radio Astronomy, Kharkov, Ukraine

Tuesday, May 25

CP18

Patterns I and Anisotropic I

3:00 PM-4:40 PM

Room: Magpie A/B

Chair: Gerhard Dangelmayr, Colorado State University

3:00-3:15 Hopf Bifurcation in Anisotropic Systems
Gerhard Dangelmayr, Colorado State University

3:20-3:35 Scroll Wave Twist in the Presence of Rotational Anisotropy
Sima Setayeshgar, California Institute of Technology; and Alain S. Karma, Northeastern University

3:40-3:55 Pattern Formation in Axial Compressors
Gregory S. Hagen and Igor Mezic, University of California, Santa Barbara

4:00-4:15 Dynamics of Spiral Waves in Weak Inhomogeneity
Matthew Hendrey, Edward Ott and Thomas M. Antonsen, Jr., University of Maryland, College Park

4:20-4:35 Spiral Instabilities in Chemical and Biological Reaction-Diffusion Systems
Michal Or-Guil and Markus Bar, Max-Planck Institut für Physik Komplexer Systeme, Dresden, Germany; and Martin Falcke, University of California, San Diego

Tuesday, May 25

CP19

Control I

3:00 PM-5:00 PM

Room: Wasatch A/B

Chair: Ioana Triandaf, U. S. Naval Research Laboratory

3:00-3:15 Quality Factor Control of Lasing Microcavities
Ioana Triandaf and Ira B. Schwartz, U. S. Naval Research Laboratory

3:20-3:35 Targeting Applying ε-Bounded Orbit Correction Perturbations
Murilo S. Baptista, University of Maryland, College Park

3:40-3:55 Combinatorial Optimization by Piecewise Continuous Dynamical Systems
Jens Starke, University of Heidelberg, Germany

4:00-4:15 Micro-Active Control of a Planar Jet
Thomas Peacock and Elizabeth Bradley, University of Colorado, Boulder

4:20-4:35 Driving Trajectories in Complex Systems
Elbert E. N. Macau, INPE–Brazilian Institute for Space Research, São Jose dos Campos, Brasil; and Celso Grebogi, University of Maryland, College Park

4:40-4:55 Double Bracket Energy Sinks and Stabilization of Principal Axis Rotations
Charles P. Coleman, Joseph C. Wilson Center for Research and Technology, Xerox Corporation

Tuesday, May 25

CP20

Chaotic Maps I

3:00 PM-5:00 PM

Room: Golden Cliff

Chair: John R. Terry, Georgia Institute of Technology

3:00-3:15 Weak Attractors and Basin Riddling

Peter Ashwin, University of Surrey, United Kingdom; *John R. Terry,* Georgia Institute of Technology

3:20-3:35 Dynamical Systems Methods Applied to Polynomial Factorization Families: A Study of Chaotic Attractors

Lora Billings, University of Delaware

3:40-3:55 Chaotic Sets Explosions: A Conjecture

Carl Robert, University of Maryland, College Park; Kathleen T. Alligood, George Mason University; Edward Ott and James A. Yorke, University of Maryland, College Park

4:00-4:15 Pseudo-Riddling in Chaotic Systems

Roman Buniy and *Ying-Cheng Lai,* University of Kansas, Lawrence; and Celso Grebogi, University of Maryland, College Park

4:20-4:35 Life Expectancy Estimations of Transient Chaos

Gabor Stépan and Gabor Csernak, Technical University of Budapest, Hungary

4:40-4:55 The Topological Pressure for a Kind of Kicked Integrable Systems

J. Ruben Luevano, Universidad Autonoma Metropolitana Azcapotzalco, México

Tuesday, May 25

CP21

Solitons I

3:00 PM-5:00 PM

Room: Maybird

Chair: Prabir Daripa, Texas A&M University, College Station

3:00-3:15 Numerical and Theoretical Studies of Some Model Equations for Bi-Directional Propagation of Nonlinear Dispersive Long Waves

Prabir Daripa, Texas A&M University, College Station

3:20-3:35 Soliton Metamorphosis

E. Infeld and G. Rowlands, University of Warwick, United Kingdom

3:40-3:55 Internal Modes and Their Radiation Damping in Vector Solitons of Coupled Nonlinear Schrödinger Equations

Jianke Yang, University of Vermont

4:00-4:15 The Secret Lives of Kinks

Grant Lythe and Salman Habib, Los Alamos National Laboratory

4:20-4:35 Multiple Pulses in Dispersive Quadratic Media

Alice C. Yew, The Ohio State University

4:40-4:55 Travelling Waves in a Model for Water Waves

L.A. Peletier and *A. I. Rotariu,* University of Leiden, The Netherlands

Tuesday, May 25

CP22

Numerics I

3:00 PM-5:00 PM

Room: Superior A

Chair: R. D. Skeel, University of Illinois, Urbana

3:00-3:15 Nonlinear Stability Analysis of Area-Preserving Integrators

R. D. Skeel, University of Illinois, Urbana; and K. Srinivas, Microsoft Corporation

3:20-3:35 The Dynamics of Adaptive Timestepping ODE Solvers

Harbir Lamba, George Mason University

3:40-3:55 Numerical Solutions of a Lienard-type Equation

Abba B. Gumel, The Fields Institute for Research in Mathematical Sciences, Toronto, Canada; and E. H. Twizell, Brunel University, Middlesex, United Kingdom

4:00-4:15 Using Differential Equation Solvers to Compute the Stable Manifold

Myong-Hee Sung and James A. Yorke, University of Maryland, College Park; and Peter Calabrese, Cornell University

4:20-4:35 On Computational Aspects of Computer-Assisted Proofs of Chaos in ODEs

Piotr Zgliczynski, Georgia Institute of Technology; and Marian Mrozek, Jagiellonian University, Krakow, Poland

4:40-4:55 Numerical Continuation of Periodic Orbits in Symmetric Hamiltonian Systems

J. Galan and E. Freire, Escuela Superior de Ingenieros de Sevilla, España; and E. J. Doedel, Concordia University, Montréal, Canada

Tuesday, May 25

CP23

Transport I

3:00 PM-5:00 PM

Room: Superior B

Chair: Vered Rom-Kedar, Courant Institute of Mathematical Sciences, New York University

3:00-3:15 Frequency Dependence of Chaotic Transport in the Presence of Diffusion
Vered Rom-Kedar, Courant Institute of Mathematical Sciences, New York University; and Andrew C. Poje, Brown University

3:20-3:35 Transport in Action-Angle-Angle Maps
Igor Mezic, University of California, Santa Barbara

3:40-3:55 Mixing in Compressible Flows
Franz David Betz and Igor Mezic, University of California, Santa Barbara

4:00-4:15 Matrix Approaches to Mixing Rates
Rua Murray, University of Victoria, Canada

4:20-4:35 Passive Tracer Dispersion in Fluids
Jinqiao Duan, Clemson University

4:40-4:55 Advection of Finite Size Neutral Particles and Control of Hamiltonian Chaos
Julyan H. E. Cartwright, CSIC-Universidad de Granada, España; and *Oreste Piro,* Universitat de les Illes Balears, Palma de Mallorca, España

Tuesday, May 25

CP24

Partial Differential Equations I

3:00 PM-5:00 PM

Room: White Pine

Chair: J. Patrick Wilber, University of Maryland, College Park

3:00-3:15 Global Attractors for a Degenerate Equation from Viscoelasticity
J. Patrick Wilber and Stuart S. Antman, University of Maryland, College Park

3:20-3:35 Asymptotic Analysis of a Spike-Type Solution of an Elliptic Equation
Leonid V. Kalachev, University of Montana

3:40-3:55 Elliptic Problems on Domains with Rapidly Oscillating Boundaries
Daniel Daners, Brigham Young University; and E. N. Dancer, University of Sydney, Australia

4:00-4:15 Continuation of Solutions to 1D and 2D Nonlinear Elliptic PDEs by the Multiquadric Method
A. Fedoseyev and *M. Friedman,* University of Alabama, Huntsville; and E. Kansa, Lawrence Livermore National Laboratory

4:20-4:35 On the Vibrations of a Plate-Beam Structure
Marie Grobbelaar, University of Pretoria, South Africa

4:40-4:55 On the Multiplicity of Solutions of Two Nonlocal Variational Problems
Xiaofeng Ren, Utah State University

Tuesday, May 25

Dinner

5:30 PM-7:00 PM

Attendees are on their own.

7:30 PM-9:30 PM
Concurrent Sessions

Tuesday, May 25

CP25

Data Analysis II

7:30 PM-9:30 PM

Room: Ballroom I

Chair: Ernest Barany, New Mexico State University, Las Cruces

7:30-7:45 Dynamical Aspects of System Identification
Ernest Barany and Richard Colbaugh, New Mexico State University, Las Cruces

7:50-8:05 Interspike Interval Embedding Theorem
Takashi Nishikawa and Celso Grebogi, University of Maryland, College Park; and Tim Sauer, George Mason University

8:10-8:25 Symbolic Sequence Approach to Biological Oscillator Dynamics
Sarah Lesher, University of Maryland, College Park; Ulrike Feudel, Universität Potsdam, Germany; and Michal Zochowski, Yale University

8:30-8:45 Error Statistics, Model Selection and Confidence in Chaotic Time-Series Prediction
Joshua T. Wood and *Erik M. Bollt,* U. S. Naval Academy

8:50-9:05 An Application of Computational Topology to Dynamical Systems
Vanessa Robins, James D. Meiss, and Elizabeth Bradley, University of Colorado, Boulder

9:10-9:25 Sunspot Cycle: A Driven Nonlinear Oscillator?
Milan Palus, Institute of Computer Science AS CR, Praha, Czech Republic; and Dagmar Novotna, Institute of Atmospheric Physics, AS CR, Praha, Czech Republic

Tuesday, May 25

CP26

Mathematical Biology II

7:30 PM-8:50 PM

Room: Ballroom II

Chair: Jonathan E. Rubin, The Ohio State University

7:30-7:45 Geometric Analysis of Population Rhythms in Neuronal Network Models with Fast Inhibitory Synapses
Jonathan E. Rubin and David Terman, The Ohio State University

7:50-8:05 The Viscous Nonlinear Dynamics of Twist and Writhe
Raymond E. Goldstein, University of Arizona; Thomas R. Powers, Harvard University; and *Chris H. Wiggins,* Courant Institute of Mathematical Sciences, New York University

8:10-8:25 Adaptive Mesh Refinement for Simulating Excitable Media
Elizabeth M. Cherry, Henry S. Greenside, and Craig S. Henriquez, Duke University

8:30-8:45 Chaos and Self-Organization in the Three-Letter Code Heteropolymer Model
Jose M. Zaldivar and Ariel Abecasis, European Commission Joint Research Center, Ispra, Italy

Tuesday, May 25

CP27

Coupled Oscillators II

7:30 PM-9:30 PM

Room: Ballroom III

Chair: M. K. Stephen Yeung, Cornell University

7:30-7:45 Time Delay in the Kuramoto Model of Coupled Oscillators
M. K. Stephen Yeung and Steven H. Strogatz, Cornell University

7:50-8:05 Dynamics of Continuous-Time Boolean Networks and Parkinsonian Tremor
Roderick Edwards, University of Victoria, Canada

8:10-8:25 Instabilities and Discrete Rotating Waves in Coupled Chaotic Oscillators
Manuel A. Matias and Esteban Sanchez, Universidad de Salamanca, España

8:30-8:45 Spatiotemporal Organization in Long Chains of Chaotic Oscillators with Impurities
Athanasios Gavrielides and Vassilios Kovanis, Air Force Research Laboratory, and Tsampikos Kottos, The Weizmann Institute of Sciences, Rehovot, Israel; and George Tsironis, University of Crete, Greece

8:50-9:05 Bifurcation Analysis of Spontaneous Symmetry-Breaking in Circular Josephson Junction Arrays
John J. Derwent and Mary Silber, Northwestern University

9:10-9:25 Synchronization in Arrays of Oscillators with Different Natural Frequencies
Leonid L. Rubchinsky and *Mikhail M. Sushchik,* Russian Academy of Sciences, Russia; and Grigory V. Osipov, Nizhny Novgorod State University, Russia

Tuesday, May 25

CP28

Patterns II/Oscillator II

7:30 PM-9:30 PM

Room: Magpie A/B

Chair: Mary Silber, Northwestern University

7:30-7:45 Parametrically Excited Surface Waves: Normal Form Symmetries and Pattern Selection
Mary Silber and Chad M. Topaz, Northwestern University; and Anne C. Skeldon, City University, Northampton Square, London, United Kingdom

7:50-8:05 Oscillatory Patterns in a Model of Autocatalytic Surface Reaction
Susanne Kömker, Universität Heidelberg, Germany

8:10-8:25 Multi-Phase Patterns in Periodically Forced Oscillatory Systems
Aric Hagberg, Los Alamos National Laboratory; Ehud Meron, Ben-Gurion University, Israel; and Christian Elphick, Centro de Fisica No Lineal y Sistemas Complejos de Santiago, Chile

8:30-8:45 Localized Traveling Waves Under the Influence of Temporal Modulation: Growing Worms and Pulses
Catherine Crawford and Hermann Riecke, Northwestern University

8:50-9:05 D_4 Equivariant Maps and the Takens-Bogdanov Bifurcation
A. M. Rucklidge, University of Cambridge, United Kingdom

9:10-9:25 Travelling Front Solutions Arising in a Chemotaxis-Growth Model
Tohru Tsujikawa, Miyazaki University, Japan

Tuesday, May 25

CP29

Control II

7:30 PM-9:30 PM

Room: Wasatch A/B

Chair: Marina Osipchuk, University of Minnesota, Minneapolis

7:30-7:45 Finite-Dimensional Control of a Nonlinear Distributed Parameter System

Marina Osipchuk, University of Minnesota, Minneapolis; Stas Y. Shvartsman and Yannis G. Kevrekidis, Princeton University; and Edriss S. Titi, University of California, Irvine

7:50-8:05 Control and Tracking in the Diamagnetic Kepler Problem

Babak Pourbohloul and Louis J. Dube, Université Laval, Québec, Canada

8:10-8:25 Feedback Linearization of Unstable Rolling Phenomenon

Bill Goodwine, University of Notre Dame; and Gábor Stépán, Technical University of Budapest, Hungary

8:30-8:45 Control of Distributed Autonomous Robotic Systems with Underlying Task Assignment

Peter Molnar, Clark Atlanta University; and Jens Starke, University of Heidelberg, Germany

8:50-9:05 Dynamic Model Reduction

David Kan, University of California, Los Angeles

9:10-9:25 Swimming Dynamics of a Shape-Changing Object

Hsi-Shang Li and I-Ming Chen, Nanyang Technological University, Singapore

Tuesday, May 25

CP30

Chaotic Maps II

7:30 PM-9:30 PM

Room: Golden Cliff

Chair: Tomasz Kapitaniak, University of Maryland, College Park; and Technical University of Lodz, Poland

7:30-7:45 Metamorphosis of Chaotic Saddle

Tomasz Kapitaniak, University of Maryland, College Park; and Technical University of Lodz, Poland; Ying-Cheng Lai, University of Maryland, College Park and University of Kansas, Lawrence; and Celso Grebogi, University of Maryland, College Park

7:50-8:05 The Breakdown of Shadowing in a Typical Physical System

Mitrajit Dutta, Edward Ott, and James A. Yorke, University of Maryland, College Park; and Ernest Barreto, George Mason University

8:10-8:25 Box Dynamics

Linda Moniz and James A. Yorke, University of Maryland, College Park

8:30-8:45 High-Quality Numerical Shadowing for Differential Equations

David E. Sigeti, John E. Pearson, and Scott M. Zoldi, Los Alamos National Laboratory

8:50-9:05 Spurious Lyapunov Exponents Computed Using the Eckmann-Ruelle Procedure

Joshua A. Tempkin, University of Maryland, College Park

9:10-9:25 Transition To High-Dimensional Chaos

Mary Ann Harrison and Ying-Cheng Lai, University of Kansas

Tuesday, May 25

CP31

Solitons II

7:30 PM-9:30 PM

Room: Maybird

Chair: Kim Rasmussen, Los Alamos National Laboratory

7:30-7:45 Large Discrete Breather Dynamics in the Presence of a Phonon Bath

Kim Rasmussen, Los Alamos National Laboratory

7:50-8:05 Radiation Loss of Dispersion-Managed Solitons in Optical Fibers

Tian-Shiang Yang and William L. Kath, Northwestern University

8:10-8:25 Solitonic Excitations on Lattice Systems

Panayotis Kevrekidis, Rutgers University

8:30-8:45 Global Boundary Stabilization of the Korteweg-de Vries-Burgers' Equation

Wei-Jiu Liu and Miroslav Krstic, University of California, San Diego

8:50-9:05 Periodic Solutions of Nonlinear Schrödinger Equation in the Strong Dispersion Management Regime

Vadim Zharnitsky, Brown University

9:10-9:25 Approximate Group Theoretic Laws for Self-focusing and Solitons

D. Subbarao and R. Uma, Indian Institute of Technology, Delhi, India

Tuesday, May 25

CP32

Numerics II

7:30 PM-9:30 PM

Room: Superior A

Chair: Kurt Lust, Cornell University

7:30-7:45 Robust Newton-Picard Methods for Bifurcation Analysis of Periodic Solutions of Partial Differential Equations
Kurt Lust, Cornell University

7:50-8:05 The Effects of Collocation Methods on Local Bifurcations of Flows
E. A. D. Foster, Memorial University of Newfoundland, Canada

8:10-8:25 Unconditionally Gradient Stable Time Marching the Cahn-Hilliard Equation
David J. Eyre, University of Utah

8:30-8:45 Finite Difference Approximations of Delay Differential Control Systems
Boris Mordukhovich and Ruth Trubnik, Morris Brown College

8:50-9:05 Numerical Computation of Solitons and Waves Using Adaptive Moving Grids
P. A. Zegeling, Utrecht University, The Netherlands

9:10-9:25 A Dynamical System Associated with Newton's Method for Parametric Approximations of Convex Minimization Problems
José Manuel Pérez Cerda Penablanca, Villa Alemana, Chile

Tuesday, May 25

CP33

Transport II

7:30 PM-8:50 PM

Room: Superior B

Chair: Harry Dankowicz, Royal Institute of Technology, Stockholm, Sweden

7:30-7:45 Slow Diffusion and Effective Stability of Dust Particles Orbiting Asteroids
Harry Dankowicz, Royal Institute of Technology, Stockholm, Sweden

7:50-8:05 Turbulent Transport by Waves
Alexander M. Balk, University of Utah

8:10-8:25 Power Spectrum of Passive Scalars in Two Dimensional Chaotic Flows
Guo-Cheng Yuan, Thomas M Antonsen, Jr., Edward Ott, and Keeyeol Nam, University of Maryland, College Park

8:30-8:45 Lagrangian Diffusion in Chaotic Fluid Flows
Fabio H. Palladino, *Ibere L. Caldas* and Gilberto Corso, Universidade de São Paulo, Brasil

Tuesday, May 25

CP34

Partial Differential Equations II

7:30 PM-9:30 PM

Room: White Pine

Chair: Renate Schaaf, Utah State University

7:30-7:45 Title to be determined
Renate Schaaf, Utah State University

7:50-8:05 Structural Analysis of Incompressible Flows
Shouhong Wang, Indiana University, Bloomington

8:10-8:25 Slow Manifolds and Inertial Manifolds in the Maxwell-Bloch Equations
Govind Menon and Gyorgy Haller, Brown University

8:30-8:45 Optimal Gap Conditions for Invariant Manifolds
Y. Latushkin and *William Layton,* University of Missouri, Columbia

8:50-9:05 Mean Curvature Laws for Spreading Solid Films
Kirk Brattkus, Southern Methodist University

9:10-9:25 On the Stabilization of Bounded Solutions for Parabolic Systems with Analytic Nonlinearity and Lyapunov Functional
Mikhail Vishnevskii, Russian Academy of Science, Siberian Branch; and Universidade Federal do Para, Guama, Para, Brasil

Wednesday, May 26

For papers with multiple authors,
the speaker is shown in italics,
if known at press time.

Wednesday, May 26

Registration Open

7:30 AM-4:00 PM

Location: Ballroom Lobby

Wednesday, May 26

IP7

Application of Dynamical Systems Theory to Spacecraft Trajectory Design Including GENESIS

8:30 AM-9:30 AM

Room: Ballrooms I, II & III

Chair: James Yorke, University of Maryland, College Park

Accomplishment of many short- and long-term science and exploration goals will require innovative spacecraft trajectory concepts and efficient design tools for analysis and implementation. For example, a number of space missions have recently been proposed that aim to take advantage of the growing scientific interest in the region of space near libration points in the Sun-Earth/Moon system. Baseline concepts for such missions are founded on solutions to the three- and four-body problems. Since no such general solutions exist, new philosophies for design must be considered; a more complete understanding of the solution space is imperative. At the same time, recent evidence supports the theory that the rich dynamics in this region of space may lead to previously undiscovered solutions. Thus, there is a current focus on obtaining a clearer understanding of the fundamental dynamics associated with the trajectory design problem, particularly in multi-body regimes, where qualitative information is needed concerning sets of solutions and their evolution. Nonlinear dynamical systems theory is a key component in progress toward that objective. The newly selected Discovery class GENESIS mission provides an opportunity to demonstrate the usefulness of dynamical systems theory in initiating trajectory design. Invariant manifolds have served as a guide to generate natural pathways and establish trajectory options near the libration points. A longer term goal in this program is to knowledgeably select and compute trajectory arcs in the multi-body problem. Such capability will support not only trajectory design, but also guidance and control, and provide a basis for evaluation of low-thrust applications in this region of space.

Kathleen C. Howell
Department of Aeronautics and Astronautics
Purdue University, West Lafayette

Wednesday, May 26

Coffee

9:30 AM-10:00 AM

Location: Ballroom Lobby

10:00 AM-12:00 PM
Concurrent Sessions

Wednesday, May 26

MS36

Topological Entropy and Average Expansion Rates: Communication, Synchrony, and Dimension

10:00 AM-12:00 PM

Room: Ballroom I

Recent work on communicating with chaos has led to renewed interest in calculating topological entropy. The speakers will describe how reducing error rates in chaos communication schemes limits the allowed symbol sequences and thus decreases the topological entropy of the system, new numerical methods for calculating topological entropy in terms of average expansion rates, the identification of new desynchronization bifurcations in coupled chaotic systems using these methods, and discuss methods based on average expansion rates which permit efficient calculation of capacity dimension.

Organizers: Ernest Barreto and Paul So
George Mason University

10:00-10:25 Dynamics of Coding in Communicating with Chaos
Erik M. Bollt, U. S. Naval Academy; and Ying-Cheng Lai, University of Kansas

10:30-10:55 Calculating Topological Entropy with an Application to Communicating with Chaos
Joeri Jacobs, Edward Ott, and *Brian R. Hunt*, University of Maryland, College Park

11:00-11:25 From Generalized Synchrony to Topological Decoherence: The Decoherence Bifurcation
*Ernest Barre*to and Paul So, Organizers

11:30-11:55 Box-counting Dimension Without Boxes: Calculating D_0 from Average Expansion Rates
Paul So and Ernest Barreto, Organizers; and Brian R. Hunt, University of Maryland, College Park

Wednesday, May 26

MS37

Geometric Approximation Methods in Ocean Modeling

10:00 AM-12:00 PM

Room: Ballroom II

One well-documented feature of global ocean circulation is its large variability in regions adjacent to coherent western-intensified currents such as the Kuroshio Current and the GulfStream. This variability limits predictability of mean properties such as the poleward heat transport, which in turn affects the accuracy in determining the Earth's climate in coupled ocean-atmosphere models. Current general circulation models (GCMs) typically underestimate this variability greatly when compared to available observations (e.g.: Topex/Poseidon). The physical origins of variability are doubtless complex in detail and include delicate potentially unstable feedback in the air-sea interaction. Variability in current GCMs may be constrained by inadequate parameterization and limited dynamical range which, at 25 km, (in global simulations) is at best marginal with respect to mesoscale physics. In this respect, the considerable recent interest among the oceanographic community in decadal and longer-period variability of the circulation only underscores the need to understand the underlying mathematical and geometrical structure in simulating complex systems such as ocean circulation and the air-sea interaction responsible for our climate. The speakers will discuss their individual approaches and recent progress in studying various dynamical systems aspects of this problem.

Organizer: Darryl D. Holm
Los Alamos National Laboratory

10:00-10:25 Extended Geostrophic Euler-Poincaré Ocean Models
J. S. Allen and P. A. Newberger, Oregon State University; and Darryl D. Holm, Organizer

10:30-10:55 Successive Bifurcations in the Oceans' Wind-driven Circulation
Michael Ghil, University of California, Los Angeles

11:00-11:25 Dynamical Systems Challenges in Assessing Ocean Transport
Christopher K. R. T. Jones, Brown University

11:30-11:55 Material Dispersion in Wind-driven Ocean Gyre
James C. McWilliams and Pavel Berloff, University of California, Los Angeles

Wednesday, May 26

MS38

Analysis and Application of Piecewise Smooth Dynamical Systems and Their Bifurcations

10:00 AM-12:00 PM

Room: Ballroom III

The main theme of this minisymposium is the analysis of piecewise-smooth dynamical systems and their bifurcations. Specifically, it has been shown that the system dynamics undergo dramatic changes when, by varying the parameters, the system trajectory (or part of it) becomes tangent to one of the boundaries dividing the phase space into different regions associated with different (smooth) system configurations. This novel type of bifurcations, termed order-collision (Nusse & Yorke 1992) and grazing (Nordmark 1991), have been shown to organize the dynamical behavior of several systems of relevance in applications such as power electronic converters, vibro-impacting mechanical devices, and friction oscillators. The speakers will discuss their latest results in this area and present some examples of relevance in applications.

Organizer: Mario di Bernardo
University of Bristol, United Kingdom

10:00-10:25 Nonsmooth Bifurcations, Sliding Orbits and Their Application in Piecewise Smooth Dynamical Systems
Mario di Bernardo, Organizer; and Chris J. Budd, University of Bath, United Kingdom

10:30-10:55 Describing the Bifurcations of Piecewise Smooth Systems
James A. Yorke, University of Maryland, College Park; and Helena E. Nusse, University of Groningen, The Netherlands

11:00-11:25 Graph Theory, Probability and Many Dimensional Piecewise Smooth Dynamical Systems
Martin E. Homer and S. J. Hogan, University of Bristol, United Kingdom

11:30-11:55 Analysis of Grazing Bifurcations in a Continuous and Piecewise Differentiable Friction Model
Arne B. Nordmark and Harry Dankowicz, Royal Institute of Technology, Stockholm, Sweden

Wednesday, May 26

MS39

Dynamics and Structures with Fractal Spectra

10:00 AM-12:00 PM

Room: Magpie A/B

Usually accepted distinction between order (periodicity or quasiperiodicity) and chaos is not complete: there are processes between order and chaos, and they are often characterized with fractal (singular continuous) power spectra. Recent studies have shown abundance of the dynamics with fractal spectra in Hamiltonian and dissipative nonlinear systems. Similar properties have been also found in solid states (quasicrystals) and in quantum chaos. This minisymposium is focused on the mechanisms of appearance of fractal spectra, the methods of their characterization, and implications for transport properties in quantum systems and solids.

Organizer: Arkady Pikovsky
Universität Potsdam, Germany

10:00-10:25 Dynamics with Singular Continuous Spectra: Mechanisms and Renormalization Group Description
Arkady Pikovsky, Organizer

10:30-10:55 Multifractal Spectra and Eigenfunction: What Determines the (Anomalous) Spreading of Wave Packets?
T. Geisel, Max-Planck-Institut für Stromungsforschung and Universität Göttingen, Germany; R. Ketzmerick, Universität Göttingen, Germany; and K. Kruse, Max-Planck Institut für Stromungsforschung

11:00-11:25 Hidden Dimer in Frenkel-Kontorova Model: Extended, Critical and Localized States in Quasiperiodic System with an Infinite Number of Steps
Indu Satija, George Mason University; and Jukka Ketoja, KCL Paper Science Center, Espoo, Finland

11:30-11:55 Dissipative and Hamiltonian Dynamics with Fractal Fourier Spectra: Symbolic Description and Multifractality
Michael Zaks and Jürgen Kurths, Universität Potsdam, Germany

Wednesday, May 26

MS40

Space Missions and Dynamical Systems

10:00 AM-12:00 PM

Room: Wasatch A/B

Modern dynamical systems theory began with Poincaré's study of the three-body problem. Space missions are increasingly more complex; demands on the orbit to solve engineering problems have grown beyond the conic-centered astrodynamic infrastructure. The delicate heteroclinic dynamics used by the Genesis Mission dramatically illustrates the need for a new paradigm: dynamical systems. Furthermore, the same dynamics has much more to say about the morphology and transport of material within the Solar System. The synergistic interplay between the natural dynamics of the Solar System and applications to engineering is a guiding principle in this field.

Organizer: Martin W. Lo
Jet Propulsion Laboratory, California Institute of Technology

10:00-10:25 From Genesis to Armageddon
Martin W. Lo, Organizer

10:30-10:55 Heteroclinic Connections and Resonance Transitions in Celestial Mechanics
Wang Sang Koon, California Institute of Technology

11:00-11:25 Tools to Explore Libration Point Orbits
Gerard Gomez, Universitat de Barcelona, España; and J. Masdemont, Universitat Politecnica de Catalunya, España

11:30-11:55 Libration Orbit Missions: Historical Perspective and Future Applications
David Folta, Goddard Space Flight Center, Greenbelt, Maryland

Wednesday, May 26

MS41

Dynamics of Scheduling Problems

10:00 AM-12:00 PM

Room: Golden Cliff

This minisymposium deals with the dynamics of scheduling and queueing problems—e.g.: queueing networks in computer science or scheduling in re-entrant manufacturing systems. Recently, the methods of dynamical systems theory have been applied to these problems which traditionally have been discussed in terms of queueing theory. The dynamics of these problems are at times chaotic; in other cases, can be related to interval exchange maps. Attempts to use control of chaos ideas to optimize have also been made. The speakers will evaluate the dynamical systems methods in this context and discusstheir relevance to realistic problems.

Organizers: Ivonne Diaz-Rivera
AT&T Research

Dieter Armbruster
Arizona State University

10:00-10:25 Stability of Queueing and Fluid Reentrant Networks
John Hasenbein, University of Texas, Austin; Jim Dai and John Vande Vate, Georgia Institute of Technology

10:30-10:55 On the Optimal Scheduling for Warehouses
Leonid A. Bunimovich, Georgia Institute of Technology

11:00-11:25 A Dynamical Systems Analysis of a Periodic Client-Server Network
James A. Walsh, Oberlin College; B. Elenbogen, University of Michigan, Dearborn; and G. R. Hall, Boston University

11:30-11:55 Periodic Orbits in Re-Entrant Manufacturing Systems
Dieter Armbruster and Ivonne Diaz-Rivera, Organizers; and Tom Taylor, Arizona State University

Wednesday, May 26

MS42

The Continuous Spectrum and Its Implications for Pattern Formation

10:00 AM-12:00 PM

Room: Maybird

This minisymposium focuses on the role of the continuous spectrum for pattern formation in nonlinear partial differential equations on unbounded domains. The effects of the continuous spectrum are relevant to dynamical behavior near shocks, spiral waves and various travelling waves. The continuous spectrum may cause bifurcations to other patterns in various ways. On one hand, discrete eigenvalues may pop out of the continuous spectrum and cross the imaginary axis, resulting in a bifurcation which can be described by a finite-dimensional dynamical system. On the other hand, the continuous spectrum itself may cross the imaginary axis, thus destabilizing the asymptotic states of the underlying wave. This phenomena can also lead to the creation of new stable spatio-temporal patterns. In contrast to the aforementioned mechanism, the dynamical system which describes this bifurcation is in general infinite-dimensional. The speakers will discuss recent progress in the analysis of these mechanisms and their consequences for the applications.

Organizers: Todd Kapitula
University of New Mexico, Albuquergue

Björn Sandstede
Ohio State University, Columbus

10:00-10:25 Front Dynamics in a Spatially Discrete System
Neil J. Balmforth, University of California, Santa Cruz

10:30-10:55 Evans Function Analysis in the Continuous Spectrum and Applications
Robert Gardner, University of Massachusetts, Amherst

11:00-11:25 Essential Instability of Pulses, and Bifurcation to Modulated Travelling Waves
Björn Sanstede, Organizer; and Arnd Scheel, Freie Universität, Berlin, Germany

11:30-11:55 Existence and Stability of Dark Solitons
Todd Kapitula, Organizer; and Jonathan Rubin, Ohio State University

Wednesday, May 26

MS43

Calcium Dynamics: Oscillations, Sparks, and Waves

10:00 AM-12:00 PM

Room: Superior A

No description was available when this program went to press.

Organizer: John E. Pearson
Los Alamos National Laboratory

10:00-10:25 The Spatial Distribution of IP_3 Receptors and the Dynamics of Intracellular Calcium
Igor Mitkov and John E. Pearson, Los Alamos National Laboratory; and Silvina Ponce Dawson, Universidad de Buenos Aires, Argentina

10:30-10:55 Calcium Dynamics in Astrocytes
Joe Raquepas, University of Utah

11:00-11:25 Elementary Events of Intracellular Calcium Signaling
Ian Parker, University of California, Irvine

11:30-11:55 Geometrical Analysis on the Intracellular Calcium Wave Propagation
Young-seon Lee and James Keener, University of Utah

Wednesday, May 26

MS44

Stochastic Stability of Dynamical Systems

10:00 AM-12:00 PM

Room: Superior B

The behavior of dynamical systems under random perturbation is of vital importance in applications and modelling. Hyperbolic dynamical systems are one class in which the behavior under random perturbation is partially understood and this knowledge has proved useful in calculating dynamical invariants and invariant measures. This minisymposium will discuss such results and also address recent results for another class of important model systems: forced or skew product systems. These results concern the existence, regularity and stability properties of invariant graphs in forced systems, and are important in understanding the stability of chaotic synchronized systems to noise, and dimension increase in recursive filters. The intended audience includes workers in nonlinear signal processing and applied dynamical systems.

Organizers: Jaroslav Stark
University College London, United Kingdom

Matthew J. Nicol
University of Manchester Institute of Science and Technology, Manchester, United Kingdom

10:00-10:25 Graphs and the Stability of Stochastically Forced Systems
Jaroslav Stark, Organizer

10:30-10:55 Approximation of Invariant Measures for Random Compositions of Maps
Anders Oberg, Uppsala University, Sweden

11:00-11:25 Stability of Attractors in Forced Systems
Matthew J. Nicol, Organizer

11:30-11:55 Attractors, Chain Transitive Sets and Invariant Measures
Fern Hunt, National Institute of Standards and Technology, Gaithersburg

Wednesday, May 26

MS45

Geometric Analysis in Hydrodynamics

10:00 AM-12:00 PM

Room: White Pine

The geometric analysis of geodesic flow on the group of volume-preserving diffeomorphisms, SDiff, answers fundamental questions about the motion of an ideal fluid, such as questions of existence and stability of the solutions to the Euler equations. Recently, great progress has been made in a number of directions: it has been proven that any two fluid configurations can be connected by a generalized flow, the exponential map on SDiff(Tn) has been show to be Fredholm, and new averaged Euler equations have been obtained as geodesics on SDiff with H1 (as opposed to L2) metric. This symposium will explore the connections between these new developments and their consequences for a better understanding of fluid motion.

Organizer: Steve Shkoller
Los Alamos National Laboratory

10:00-10:25 Geometry and Curvature of New Diffeomorphism Groups and the Averaged Euler Equations
Steve Shkoller, Organizer

10:30-10:55 The SU(n) Approximation to the 2D Averaged Euler Equations
Sergey Pekarsky, California Institute of Technology

11:00-11:25 A Nonlinear Analysis of the Averaged Euler Equations
Jerrold E. Marsden, California Institute of Technology

11:30-11:55 New Pressure Estimates for the 2D Euler Equation
Peter Topping, Mathematical Sciences Research Institute

Wednesday, May 26

Lunch

12:00 PM-1:30 PM

Attendees are on their own.

Wednesday, May 26

IP8

Quantitative Studies of the Fertilization Wave in Eggs

1:30 PM-2:30 PM

Room: Ballrooms I, II & III

Chair: John Guckenheimer, Cornell University

Propagating waves of calcium ions have been observed in a wide variety of living cells. These waves function as part of the second messenger role of calcium in transmitting signals from hormone receptors and other molecular detectors in the plasma membrane. In egg cells, calcium waves are initiated by the egg-sperm fusion event and have been observed in every species studied. After dormancy for many years, the fertilization calcium wave stimulates events that activate metabolism and development of the egg. The speaker will discuss a model of calcium handling in eggs from the African frog, Xenopus leavis, and describe simulations in two- and three-dimensions that help to understand the mechanisms of initiation, propagation and termination of the wave.

Joel Keizer
Institute of Theoretical Dynamics, University of California, Davis

Wednesday, May 26

Coffee

2:30 PM-3:00 PM

Location: Ballroom Lobby

3:00 PM-5:00 PM
Concurrent Sessions

Wednesday, May 26

CP35

Data Analysis III

3:00 PM-4:40 PM

Room: Ballroom I

Chair: Boris Naujoks, Universität Dortmund, Germany

3:00-3:15 Nonlinear Dynamic Signal Processing of Chaotic Noise in a Real Channel
Kevin M. Short, University of New Hampshire

3:20-3:35 Prediction and Noise Filtering in Dynamical Systems: A Neural Network Approach
Gustavo Deco, Siemens AG, Munich, Germany; and Louis J. Dube, Université Laval, Québec, Canada

3:40-3:55 The AWARE (Advanced Warning Against Runaway Events) Project
Fernanda Strozzi, Libero Istituto Universitario Carlo Cattaneo, Castellanza, Italy; and *Jose M. Zaldivar,* European Commission Joint Research Center, Ispra, Italy

4:00-4:15 Tracking Doppler-Shifted Chaotic Waveforms
Daniel W. Hahs and Ned J. Corron, Dynetics, Inc., Huntsville, Alabama

4:20-4:35 Modeling of Large-Scale Complex Adaptive Systems
Radoslaw Zapert and Huanrui Hu, PricewaterhouseCoopers LLP

Wednesday, May 26

CP36

Synchronization

3:00 PM-5:00 PM

Room: Ballroom II

Chair: Epaminondas Rosa, Jr., University of Miami

3:00-3:15 Transition to Phase Synchronization of Chaos
Epaminondas Rosa, Jr., University of Miami

3:20-3:35 Synchronized Finger Tapping and $1/f^{\alpha}$ Type Long Memory Processes
Mingzhou Ding, Florida Atlantic University

3:40-3:55 Weak Synchronization of Chaotic Coupled Map Lattices
Stefano Boccaletti, Universidad de Navarra, España

4:00-4:15 Understanding Phase Synchronization in Terms of Periodic Orbits
Jürgen Kurths, Universität Potsdam, Germany

4:20-4:35 Destruction of Resonances in Two-Mode Quasilinear Dynamical Systems
Yury A. Tsarin and Dmytro M. Vavriv, Institute of Radio Astronomy, Kharkov, Ukraine

4:40-4:55 Laser Spectral Waves: from Pattern Formation to Spatiotemporal Chaos
Jerome Plumecoq, *Christophe Szwaj,* Dominique Derozier, Marc Lefranc and Serge Bielawski, Université des Sciences et Technologies de Lille, Villeneuve d'Ascq Cedex, France; and Thomas Erneux, Universiteit Libre de Bruxelles, Belgium

Wednesday, May 26

CP37

Pattern Formation in the Cahn-Hilliard Model — Part II of II

3:00 PM-5:00 PM

Room: Ballroom III

Chair: Thomas Wanner, University of Maryland, Baltimore County

For Part I, see MS33

In the forty years since its introduction, the Cahn-Hilliard model has proved its ability to exhibit pattern formation and phase separation phenomena like those being observed in binary metallic alloys. Therefore, understanding the dynamical behavior of the model is of immediate interest in materials sciences. While existing mathematical results for the one-dimensional model provide a fairly complete picture of its rich dynamics, most of the current research focuses on the physically more relevant two- and three-dimensional models, as well as their discrete and multi-component counterparts. The talks in the minisymposium will cover a broad spectrum of these recent studies.

3:00-3:15 Existence of Connecting Orbits in Cahn-Hilliard
Konstantin Mischaikow, Georgia Institute of Technology

3:20-3:35 Pattern Formation and Spatial Entropy in Spatially Discrete Cahn-Hilliard Equations
Erik S. Van Vleck, Colorado School of Mines

3:40-3:55 Spinodal Decomposition for the Cahn-Hilliard Equation
Evelyn Sander, George Mason University; Stanislaus Maier-Paape, Georgia Institute of Technology; and Thomas Wanner, University of Maryland, Baltimore County

4:00-4:15 Allen-Cahn/Cahn-Hilliard Systems with Degenerate Mobility
Amy Novick-Cohen, Technion–Israel Institute of Technology, Israel

4:20-4:35 Pattern Evolution in the Discrete Cahn-Hilliard Equation
Christopher P. Grant, Brigham Young University

4:40-4:55 Spinodal Decomposition for the Cahn-Hilliard-Cook Equation-Linear Theory
Dirk Blömker, Universität Augsburg, Germany

Wednesday, May 26

CP38

Nonlinear Waves

3:00 PM-5:00 PM

Room: Magpie A/B

Chair: Edgar Knobloch, University of California, Berkeley

3:00-3:15 Dynamics of Counter-propagating Waves in Parametrically Forced Systems
Edgar Knobloch, University of California, Berkeley; Carlos Martel and Jose M. Vega, Universidad Politecnica de Madrid, España

3:20-3:35 Linear Conversion of Parallel Waves
Allan N. Kaufman, Lawrence Berkeley National Laboratory and University of California, Berkeley; E. R. Tracy, College of William & Mary; James J. Morehead and Alain J. Brizard, Lawrence Berkeley National Laboratory

3:40-3:55 Dynamics, Bifurcations, and Stability of Fronts in the Optical Parametric Oscillator
J. Nathan Kutz, University of Washington; T. Erneux, Universiteit Libre de Bruxelles, Belgium

4:00-4:15 Fronts and Pulses in Reaction-Diffusion Equations and Their Stability
Geertje M. Hek, Utrecht University, The Netherlands

4:20-4:35 Dynamics of Solitary Pulses in Isotropic and Anisotropic Reaction Diffusion Systems
J. Krishnan, Ioannis G. Kevrekidis, Princeton University; Koen Engelborghs and Dirk Roose, Catholique Universiteit Leuven, Belgium; and Markus Bar, Max-Planck Institut für Physik Complexer Systeme, Dresden, Germany

4:40-4:55 The Coupled, Weakly-Nonlinear Evolution of Two Counter-Rotating Waves and the Associated Streaming Flow in Finite Geometries
Maria Higuera, José A. Nicolas, and José M. Vega, Universidad Politecnica de Madrid, España

Wednesday, May 26

CP39

Applications II

3:00 PM-5:00 PM

Room: Wasatch A/B

Chair: Louis Pecora, U. S. Naval Research Laboratory

3:00-3:15 Detecting Invariant Manifolds in Time Series: Biological Data
Louis Pecora, U. S. Naval Research Laboratory

3:20-3:35 Weather Prediction and Residual Delay Maps: Isolating Regions of Atmospheric Nonlinearity to Compare Different Atmospheric Models
Dhanurjay Patil, University of Maryland, College Park

3:40-3:55 Nonlinear Techniques for Detecting Physical Forcing of Ecological Systems: A Working Example
Paul Dixon, University of California, San Diego

4:00-4:15 Nonlinear and Nonequilibrium Phenomena in Cell Motility
Josef Kas, University of Texas, Austin

4:20-4:35 Nonlocal Reaction-Diffusion Equations for Microwave Heating Applications
Amitabha Bose and Gregory Kriegsmann, New Jersey Institute of Technology

4:40-4:55 Spatially Complex Localization in Twisted Constrained Elastic Rods
G. H. M. van der Heijden and J. M. T. Thompson, University College London, United Kingdom; and A. R. Champneys, University of Bristol, United Kingdom

Wednesday, May 26

CP40

Applications III — Orbital Dynamics and Plasma Dynamics

3:00 PM-5:00 PM

Room: Golden Cliff

Chair: Robert L. Warnock, Stanford Linear Accelerator Center

Orbital Dynamics

3:00-3:15 Power Limited Optimal Rendezvous Between Spacecraft
Yechiel Crispin and Virginie Guerre, Embry-Riddle University

3:20-3:35 Evolving Perturbed Hamiltonian Systems with Lie Transformations
Liam M. Healy, U. S. Naval Research Laboratory

3:40-3:55 An Optimal Control Problem for Satellite Dynamics via Wavelets
Antonina Fedorova and *Michael Zeitlin*, Russian Academy of Sciences, St. Petersburg, Russia

Plasma Dynamics

4:00-4:15 Solutions of the Vlasov-Fokker-Planck Equation for Electrons in a Storage Ring
Robert L. Warnock, Stanford Linear Accelerator Center

4:20-4:35 Experimental Observation of Chaos in a Plasma Discharge Tube
Jonathan A. Walkenstein, William B. Pardo, Torben N. Buch, Marco Monti, and Epaminondas Rosa, Jr., University of Miami

4:40-4:55 Dynamics of a Chaotic Magnetic Limiter in Tokamaks
Kai Ullmann and *Ibere L. Caldas*, Universidade de São Paulo, Brasil

Wednesday, May 26

CP41

Forced Biosystems

3:00 PM-4:40 PM

Room: Maybird

Chair: Ulrike Feudel, Universität Potsdam, Germany

3:00-3:15 Complex Behavior in Quasiperiodically Forced Biological Oscillators
Ulrike Feudel, Universität Potsdam, Germany

3:20-3:35 Embedding and Reconstruction of Forced Systems
Jaroslav Stark, University College London, United Kingdom

3:40-3:55 Detecting Weak Interaction from Bivariate Data
Michail Rosenblum, J. Kurths, and C. Schaefer, Universität Potsdam, Germany; P. Tass, Heinrich-Heine Universität, Germany

4:00-4:15 Synchronization of Noisy Systems by Stochastic Signals
Alexander Neiman and Frank Moss, University of Missouri, St. Louis; Lutz Schimansky-Geir, Humboldt Universität, Germany; Boris Shulgen and James Collins, Boston University

4:20-4:35 Modelling Edge Detection Using A Network of Pulse-Coupled Neurons
Robert H. Clewley, University of Bristol, United Kingdom

Wednesday, May 26

CP42

Patterns III

3:00 PM-5:00 PM

Room: Superior A

Chair: Gemunu H. Gunaratne, University of Houston

3:00-3:15 An Analysis of Cellular Flame Patterns
Gemunu H. Gunaratne, University of Houston

3:20-3:35 Instabilities of Hexagonal Pattern in the Presence of Rotation
Blas Echebarria and Hermann Riecke, Northwestern University

3:40-3:55 Super-Patterns and Parameter Collapse in Reaction-Diffusion Systems
Stephen L. Judd and Mary Silber, Northwestern University

4:00-4:15 Cross-Newell Equations for Triangles and Hexagons
Rebecca B. Hoyle, University of Cambridge, United Kingdom

4:20-4:35 Multibump Patterns Near a Co-Dimension 2 Point
Vivi Rottschafer, University of Utrecht, The Netherlands, and Boston University

4:40-4:55 Modal Decomposition of Hopping States in Cellular Flames
Antonio Palacios, Michael Gorman, and Gemunu Gunaratne, University of Houston

Wednesday, May 26

CP43

Vortex Dynamics

3:00 PM-5:00 PM

Room: Superior B

Chair: Monika Nitsche, University of New Mexico, Albuquerque

3:00-3:15 Chaotic Dynamics in Vortex Cores
Monika Nitsche, University of New Mexico, Albuquerque; and Robert Krasny, University of Michigan, Ann Arbor

3:20-3:35 Instabilities of Vortex Filaments in Oscillatory Media
Guillaume Rousseau and Hugues Chate, CEA, Centre d'Etudes de Saclay, Gif-sur-Yvette, France; and Raymond Kapral, University of Toronto, Canada

3:40-3:55 Tracer Dynamics in a Flow of Driven Vortices
Fred Feudel and Annette Witt, Universität Potsdam, Germany; and Celso Grebogi, University of Maryland, College Park

4:00-4:15 Topological Bifurcations in the Vortex Breakdown
Morten Brons, Lars K. Voigt and Jens N. Sorensen, Technical University of Denmark, Lyngby, Denmark

4:20-4:35 Five Point Vortices Which Exhibit Relaxation Oscillation
Tatsuyuki Nakaki, Hiroshima University, Japan

Wednesday, May 26

CP44

Polymers

3:00 PM-5:00 PM

Room: White Pine

Chair: Qi Wang, Indiana University, Purdue University

3:00-3:15 Capillary Instability in Free Surface Jets of Liquid Crystal Polymers
Qi Wang, Indiana University, Purdue University

3:20-3:35 Numerical Simulations of Complex Flows of LCPs Based on the Doi Theory
Jimmy Feng, Levich Institute, City University of New York

3:40-3:55 Stress Selection and Phase Separation in the Doi Model for Solutions of Liquid Crystalline Polymers
Peter D. Olmsted, University of Leeds, United Kingdom

4:00-4:15 Nonisothermal Spinning of Lyotropic and Thermotropic Liquid Crystalline Polymers
Hong Zhou, University of North Carolina, Chapel Hill

4:20-4:35 A Continuum-Mechanical Theory for Nematic Elastomers
Eliot Fried, University of Illinois, Urbana-Champaign

Wednesday, May 26

Dinner

5:00 PM-7:00 PM

Attendees are on their own.

Wednesday, May 26

Poster Set-up

Poster boards will be available for presenters in Ballroom I, II, and III. Set-up is to be finished by 7:30 PM.

6:30 PM-7:30 PM

Room: Ballroom I, II & III

Wednesday, May 26

Poster Session and Dessert Reception

7:30 PM-9:30 PM

Room: Ballroom I, II & III

Distributions of Rotation Numbers
Todd Ray Young, Ohio University, and IPST, University of Maryland, College Park

Controlling Transient Chaos in Deterministic Flows with Applications to Electrical Power Systems and Ecology
Mukeshwar Dhamala and Ying-Cheng Lai, University of Kansas

A Study of a Forced Oscillator in an Electric Power System
Alona Ben-Tal and Vivien Kirk, The University of Auckland, New Zealand

Markovian Analogue to Phase Transitions in Coupled Chaotic Map Lattices
Francisco Sastre and Gabriel Perez, CINVESTAV-IPN, Unidad Merida, México

1:2 Resonance Mediated Transmission Band Gap Opening in a 1-d Nonlinear Discrete Periodic Medium
Anna V. Georgieva, Chemical Industry Institute of Toxicology; Thomas Kricherbauer, Universität München, Germany; and Stephanos Venakides, Duke University

Correlation of Inhaled Formaldehyde Flux Predictions with Regional DNA-Protein Crosslink Measurements in Rat Nasal Passages
Anna V. Georgieva, Paul Schlosser and Julia Kimbell, Chemical Industry Institute of Toxicology

Dynamical Systems as Kolmogorov Data Compressors
Todd K. Moon, Utah State University

Matched Asymptotic Expansions and Smolder Combustion
Daniel A. Schult, Colgate University

Cumulative Wavelength as a Source of Dynamical Information of the Molecular Gas Spectra
Vladimir P. Solovjov and Brent W. Webb, Brigham Young University

A Mathematical Model of True Polar Wander
Melvin B. Leok and Jerrold E. Marsden, California Institute of Technology

Melnikov's Method, Bifurcations of Codimension One and Two and Exponentially Small Splittings of Separatrices in Forced Oscillators
Kazuyuki Yagasaki, Gifu University, Japan

Chaotic Transitions and Low-Frequency Fluctuations in Semiconductor Lasers with Delayed Optical Feedback
Ruslan L. Davidchack and Ying-Cheng Lai, University of Kansas, Lawrence; Athanasios Gavrielides and Vassilios Kovanis, Air Force Research Laboratory DELO

Dynamics of the Four-Level Laser with Injected Signal
Peter A. Braza, University of North Florida; and Carlos L. Pando, Universida Autonoma de Puebla, México

Random and Deterministic Perturbation of a Class of Skew-Product Systems
Demetris Hadjiloucas, David Broomhead, and Matthew Nicol, UMIST, Manchester, United Kingdom

Unstable Periodic Orbits of Area Preserving Mappings
Babak Pourbohloul and Louis J. Dube, Université Laval, Québec, Canada

Mode Interactions of Globally-Coupled Phase Oscillators
John David Crawford and *Eric J. Hildebrand,* University of Pittsburgh

A Generalized Single Wave Model for Unstable Electrostatic Waves
Anandhan Jayaraman and John David Crawford, University of Pittsburgh

Microextensive Chaos of a Spatially Extended System
Shigeyuki Tajima and Henry S. Greenside, Duke University

Resonant Pattern Formation in a Reaction-Diffusion PDE System
Alexandre Ardelea, Anna L. Lin and Harry L. Swinney, University of Texas, Austin

Possible Existence of Stochastic Resonances in Electrotelluric Time Series
Alejandro Ramirez-Rojas, Carlos G. Pavia-Miller, and Francisco Cervantes-De la Torre, Universidad Autonoma Metropolitana Azcapotzalco, México; and Fernando Angulo-Brown, Escuela Superior de Fisica y Matematicas, IPN, México

Symbolic Analysis of Non-Stationary Time Series
E. R. Tracy, College of William and Mary; and Dennis M. Weaver, Saint Leo College

Libration Point Invariant Manifolds and Solar System Dynamics
Shane D. Ross, California Institute of Technology; and Martin W. Lo, Jet Propulsion Laboratory

Models for Insect Locomotion I: Dynamics and Stability in the Horizontal Plane
John Schmitt and Philip Holmes, Princeton University

Karhunen-Loeve Decomposition of Peripheral Blood Flow
Mario Hozic and Aneta Stefanovska, University of Ljubljana, Slovenia

Modeling and Controlling Molecular Dynamics
Sonja G. Schirmer, John V. Leahy, and Marvin D. Girardeau, University of Oregon

Symmetry Breaking of Eddies in Expanding Flows
Shinya Watanabe, Ibaraki University, Mito, Japan

Boundary Effects on Complex Ginzburg-Landau Dynamics
Victor M. Eguiluz, *Emilio Hernandez-Garcia,* and Oreste Piro, Campus Universitat de les Illes Balears, Palma de Mallorca, España

Defect Dynamics in the Vector Complex Ginzburg-Landau Equation
Emilio Hernandez-Garcia, Pere Colet, and Maxi San Miguel, Campus Universitat de les Illes Balears, Palma de Mallorca, España; and Miguel Hoyuelos, Universidad Nacional del Mar del Plata, Argentina

A Fractal Analysis of Electrotelluric Time Series
Francisco Cervantes-De la Torre, Alejandro Ramirez-Rojas and Carlos Pavia-Miller, UAM-AZCAPOTZALCO, México; and Fernando Angulo-Brown, Instituto Politecnico Nacional, México

Color Map of Lyapunov Exponents of Invariant Sets
Marco Monti, William B. Pardo, Jonathan A. Walkenstein, and Epaminondas Rosa, Jr., University of Miami; and Celso Grebogi, University of Maryland, College Park

Transition to High-Dimensional

Chaos in Coupled Oscillators
Lonnie Sauter and Ying-Cheng Lai, University of Kansas, Lawrence

The Myltisymplectic Geometry and Variational Integrators for the Camassa-Holm Equation
Shinar O. Kouranbaeva, University of California. Santa Cruz; and Steve Shkoller, Los Alamos National Laboratory

Synchronization and Communication Using Chaotic Frequency Modulation
A. R. Volkovskii and L. S. Tsimring, University of California, San Diego

Nonlinear Behavior of the Inner Ear
David E. Lerner and Darius Amani-Taleshi, University of Kansas, Lawrence; and Mark Chertoff, University of Kansas Medical Center

Identification of Decision Systems
R. Colbaugh, K. Glass, and E. Barany, New Mexico State University

Identification of Hybrid Dynamical Systems II: Case Studies
K. Glass, R. Colbaugh, T. S. Melker, and E. Barany, New Mexico State University

Identification of Hybrid Dynamical Systems I: Theory
R. Colbaugh, K. Glass, and E. Barany, New Mexico State University

Unstable Periodic Orbits and the Natural Measure of Nonattracting Chaotic Saddles
Mukeshwar Dhamala and Ying-Cheng Lai, University of Kansas

A Geometric Method for Calculating Diffusive Traveling Waves in Coupled Systems
David J. Eyre, University of Utah

Forecasting High Waters at Venice Lagoon using Chaos Theory Techniques
Jose M. Zaldivar, European Commission Joint Research Center, Ispra, Italy; Fernanda Strozzi, Libero Istituto Universitarío Carlo Cattaneo, Castellanza, Italy; Eugenio Gutierrez, European Commission Joint Research Center, Ispra, Italy; and Alberto Tomasin, Universita Venice, Italy

Optimal Targeting of Chaos
Erik M. Bollt, U. S. Naval Academy; and Eric J. Kostelich, Arizona State University

On the Inverse Frobenius-Perron Problem (IFPP): Global Stabilization of Arbitrary Invariant Measures
Erik M. Bollt, U. S. Naval Academy

A Novel Measure of Nonstationarity in Dynamical Systems
Louis J. Dube and Frederic Beaulieu, Université Laval, Québec, Canada; and Gustavo Deco, Siemens AG, Munich, Germany

Extraction of Teleseismic Signal Waveforms from Background Noise Using Nonlinear Dynamic Forecasting
Kevin M. Short, University of New Hampshire

Filling the Rotation Interval at Discontinuous Bifurcations: A Continued Fraction
Carl Robert, University of Maryland, College Park; Kathleen T. Alligood and Tim Sauer, George Mason University

Critical Exponents for Higher Dimensional Crises
Carl Robert, Celso Grebogi, Edward Ott, and James A. Yorke, University of Maryland, College Park

Extracting Signals from Chaotic Laser Data
John B. Geddes and Kevin M. Short, University of New Hampshire

Average Expansion Rates and Dimension of Strange Nonchaotic Attractors
Paul So and Ernest Barreto, George Mason University; and Ulrike Feudel, Universität Potsdam, Germany

From High Dimensional Chaos to Stable Periodic Orbits: The Structure of Parameter Space
Murilo S. Baptista, Ernest Barreto, Celso Grebogi, University of Maryland, College Park

The Destruction of Horseshoes in 2D and 4D Symplectic Maps
David G. Sterling, Holger Dullin. James D. Meiss, University of Colorado, Boulder

Binary Fluid Convection as a 2x2 Matrix Problem
Laurette Tuckerman, LIMSI-CNRS, Orsay, France

Oscillatory Neurocomputers With Dynamic Connectivity
Eugene M. Izhikevich, Arizona State University

Pulse Dynamics in Isotropic and Anisotropic Reaction-Diffusion Systems
J. Krishnan and Ioannis G. Kevrekidis, Princeton University; Koen Engelborghs, Dirk Roose and Markus Baer, Catholique Universiteit Leuven, Belgium; and Max-Planck Institut für Physik komplexer Systeme, Dresden, Germany

Subsystem Recurrences in High-dimensional Chaotic Systems
Scott M. Zoldi, Los Alamos National Laboratory

Big Islands in Dispersing Billiard-like Potentials
Vered Rom-Kedar, Courant Institute of Mathematical Sciences, New York University; and Dmitry Turaev, Weierstrass Institute for Applied Analysis and Stochastics, Berlin, Germany

Dispersion Relation and Oscillons in a Continuum Model for Vibrated Granular Media
Hermann Riecke, Northwestern University; and Jens Eggers, Universität Essen, Germany

Control and Synchronization of Spatially Extended Systems
Ulrich Parlitz and Lutz Junge, Universität Göttingen, Germany

Prediction of Spatio-Temporal Time Series Based on Reconstructed Local States
Ulrich Parlitz and Christian Merkwirth, Universität Göttingen, Germany

Wavelet Approach to Hamiltonian Problems
Antonina Fedorova and *Michael Zeitlin,* Russian Academy of Sciences, St. Petersburg, Russia

Optimal Chaos Control Through Reinforcement Learning
Sabino Gadaleta and *Gerhard Dangelmayr,* Colorado State University, Fort Collins

Periodic Solutions of Neutral Functional Differential Equations: A Case Study
Koen Engelborghs and Dirk Roose, Catholique Universiteit Leuven, Belgium; and Tatyana Luzyanina, Institute for Mathematical Problems in Biology, Moscow, Russia

Dynamical Systems Methods for Geophysical and Environmental Modeling
Jinqiao Duan, Clemson University

The Hopf Fibration and its Applications
Mason A. Porter, Cornell University

Fractal Dimension in Higher-Dimensional Chaotic Scattering Systems
David Sweet, Edward Ott, and James Yorke, University of Maryland, College Park

Lie Transfer Map Propagation of Perturbed Keplerian Systems
Liam M. Healy, Naval Research Laboratory

Exponentially Long Equilibration Times in a 1-D Classical Gas
Giancarlo Benettin, Universitá di Padova, Italy; and *PoulHjorth,* Technical University of Denmark

Thin Liquid Films: Flows On An Imperfect Surface
Ljubinko (Lou) Kondic, Javier Diez, and Andrea Bertozzi, Duke University

Complex Dynamics in the 1:3 Steady Mode Interaction
Jeff Porter and Edgar Knobloch, University of California, Berkeley

A Variational Principle for the Amplitude of Limit Cycles
Rafael Benguria and *M. Cristina Depassier,* P. U. Catolica de Chile, Santiago, Chile

Unstable Periodic Orbits and the Transition to High-Dimensional Chaos
Ruslan L. Davidchack and Ying-Cheng Lai, University of Kansas, Lawrence

Chaotic Choreography
Elizabeth Bradley, University of Colorado, Boulder; and Joshua Stuart, Stanford University Medical Center

Elimination of Quantization-Induced Limit Cycles in Nonlinear Dynamical Simulations
Michael G. Bailey and R.H. Cofer, Florida Institute of Technology

Multiple Scales Averaging of Parametric Gain Equations with Periodic Domain Poling
Richard O. Moore and William L. Kath, Northwestern University

The Breakdown of Shadowing in a Typical Physical System
Mitrajit Dutta and Edward Ott, University of Maryland, College Park; Ernest Barreto, George Mason University; and James A. Yorke, University of Maryland, College Park

Nonlinear Polarization Dynamics in Mode-Locked Optical Fiber Lasers
Arnold D. Kim and J. Nathan Kutz, University of Washington; and David J. Muraki, Courant Institute of Mathematical Sciences, New York University

Information Transmission Through Chaotic Modeling of Language
Murilo S. Baptista, Epaminondas Rosa, and Celso Grebogi, University of Maryland, College Park

Bifurcation and Dynamics of a Simple Power System Model
Jon P. Wilson, University of Bath, United Kingdom

Diffusion in Action Space for Weakly Nonintegrable Hamiltonian Systems
Demin Yao and Jack Shi, University of Kansas

Simulation of Socio-Economic Development in Two Areas Competing for Scarce Resources in Tenerife, Canary Islands
José Manuel Gonzalez, Universidad de La Laguna, Canary Islands, España

Stochastically Forced Navier-Stokes Equation
Jonathan C. Mattingly, Stanford University; and Ya. G. Sinai, Princeton University

Solitary-Wave Solutions of a Nonlinearly Dispersive Hamiltonian System
Yi A. Li, Los Alamos National Laboratory

A Two-Dimensional Biofilm Model with Fingering Instabilities
Nicholas G. Cogan, Jack Dockery, Isaac Klapper, and Mark Pernarowski, Montana State University

1-D Biofilm Models
L. A. Pritchett, Montana State University

Particle Dynamics and Mixing in the Frequency Driven Kelvin Cat Eyes Flow
Elia Eschenazi, Xavier University of Louisiana; *Yamlak Tsega,* Tulane University; and Stephen Rodriguez, Xavier University of Louisiana

Wednesday, May 26

Poster Session and Reception Adjourns

9:30 PM

All displays should be completely removed from the poster boards by 10:00 PM.

Thursday, May 27

For papers with multiple authors, *the speaker is shown in italics,* if known at press time.

Thursday, May 27

Registration Open

7:30 AM-10:00 AM

Location: Ballroom Lobby

Thursday, May 27

IP9

DNA Evolution and Computation

8:30 AM-9:30 AM

Room: Ballrooms I, II & III

Chair: Harry Swinney, University of Texas, Austin

DNA is at the same time the support of genetic information and a polymer. The speaker will describe experiments studying those two aspects. Single stranded DNA can form secondary structures by self hybridization, defining a hairpin-loop. The dynamics of opening and closing of the structure and the elasticity of the loop depends on the information inscribed. The speaker will discuss molecular recognition by annealing the hairpin to a complementary structure, and the optimal sensitivity can be achieved by varying the length and the composition of the stem. He will present a study of microarrays of such hairpin-loops to measure gene expression, and describe protein evolution in the laboratory using ribosome display and a cycle of mutation followed by selection.

Albert J. Libchaber
Center for Studies in Physics and Biology, Rockefeller University

Thursday, May 27

Coffee

9:30 AM-10:00 AM

Location: Ballroom Lobby

10:00 AM-12:00 PM
Concurrent Sessions

Thursday, May 27

MS46

Modeling of Chaotic Systems

10:00 AM-12:00 PM

Room: Ballroom I

Scientists attempt to understand physical phenomena by constructing models, and a fundamental goal is to develop models whose solutions reflect the nature of the physical process. A dynamical model uses simplifying assumptions in the hope of capturing the essential characteristics in the evolution of a physical system over time. The development of models is based on experiments or observations. The speakers in this minisymposium will discuss different approaches to using data to construct models and address the difficulties in modeling dynamical processes with high complexity.

Organizers: Ulrike Feudel
Universität Potsdam, Germany

Celso Grebogi
University of Maryland, College Park

10:00-10:25 Obstruction to Modeling
Celso Grebogi, Organizer

10:30-10:55 Construction of ODE Models from Experimental Data
Holger Kantz, Rainer Hegger, and Ralf-Peter Kapsch, MPI Physik Komplexer Systeme, Dresden, Germany

11:00-11:25 Reconstruction of High-Dimensional Nonlinear Models from Data
Henning Voss and Jürgen Kurths, Universität Potsdam, Germany

11:30-11:55 Modeling Multistable Systems
Ulrike Feudel, Organizer; and Suso Kraut, Universität Potsdam, Germany

Thursday, May 27

MS47

Complex Synchronization in Neuroscience

10:00 AM-12:00 PM

Room: Ballroom II

Synchronization phenomena in neuroscience are of great current interest particularly for information processing in nervous systems and neurological diseases. The speakers will present new achievements in the understanding of synchronization processes by means of nonlinear dynamics and an approach based on phenomena of hidden phase synchronization recently found in weakly coupled chaotic systems. They will discuss new techniques for the reliable identification of complex synchronization from bi- and multivariate noisy data and to apply this concept to neurophysiological measurements. They will also describe work on complex spatio-temporal dynamics of neural systems.

Organizer: Jürgen Kurths
Universität Potsdam, Germany

10:00-10:25 Detection of n:m Phase Synchronization from Noisy Data
Jürgen Kurths, Organizer; Michael Rosenblum, Universität Potsdam; and Peter Tass, Universität Düsseldorf, Germany

10:30-10:55 Phase Locked Brain Activity in the Motor System
Peter Tass and Alfons Schnitzler, Universität Düsseldorf, Germany; Misha Rosenblum, Universität Potsdam; and Jürgen Kurths, Organizer

11:00-11:25 Synchronization of the Stochastic Dynamics of Paddlefish Electroreceptors Cells
Frank Moss and Alexander Neiman, University of Missouri, St Louis

11:30-11:55 Complex Spatio-Temporal Dynamics of Neural Networks
Kazuyuki Aihara, University of Tokyo, Japan

Thursday, May 27

MS48

Chaotic Advection in Temporally Chaotic Flows

10:00 AM-12:00 PM

Room: Ballroom III

Advection in temporally periodic hydrodynamical flows has become one of the most appealing applications of chaos theory with an ample possibility of experimental investigations. In contrast to periodic flows, much less is known about the passive advection in temporally nonperiodic, most interestingly, chaotic flows. They are, of course, more general and have more potential applications including environmental ones. The aim of this minisymposium is to present concepts and approaches to describe advection in temporally chaotic flows and to characterize the degree of chaoticity of these processes, like the concept of indecomposable continua, the use of random maps, fractals, and the way to handle general time dependences.

Organizers: Miguel A. F. Sanjuan
Universidad Rey Juan Carlos, Mostoles-Madrid, España

Tamás Tél
Eötvös University, Budapest, Hungary

10:00-10:25 Indecomposable Continua in Fluid Flow Past an Array of Cylinders
Miguel A. F. Sanjuan, Organizer

10:30-10:55 Advection in Chaotically Time-Dependent Open Flows
Tamás Tél, Organizer

11:00-11:25 Mixing and Diffusion in Aperiodic Flows
George Haller, Brown University

11:30-11:55 The Fractal Nature of Vorticity at High Reynolds Number
Edward Ott, University of Maryland, College Park

Thursday, May 27

MS49

Applied Dynamics and Invariant Manifolds in Continuum Mechanics

10:00 AM-12:00 PM

Room: Magpie A/B

Structural mechanics in many systems of interest to defense and industry exhibits nonlinear spatio-temporal dynamical behavior (including chaos) in both theory and experiment. Such fascinating behavior is necessary to understand so that unwanted vibrations may be controlled, and the lifetime of structures may be extended. The papers presented in this minisymposium deal with the mathematical analysis of models and experimental data of nonlinear structures which exhibit nonlinear vibrations and nonlinear modal interactions. The speakers will apply analytic methods to demonstrate that the attractors are finite dimensional, and may be represented by invariant manifolds which slave the motion.

Organizers: Ira B. Schwartz and Ioannis T. Georgiou
U. S. Naval Research Laboratory

10:00-10:25 Nonlinear Normal Modes in a System with Nonholonomic Constraints
Richard H. Rand and Deepak V. Ramani, Cornell University

10:30-10:55 Nonlinear Modal Interactions in a Kicked Flexible Rod
Joseph P. Cusumano, Pennsylvania State University

11:00-11:25 Exponential Attractors and Inertial Dynamical Systems in Continuum Mechanics
Basil Nicolaenko, Arizona State University

11:30-11:55 Proper Orthogonal Decomposition Analysis of the Interaction Dynamics of Coupled Systems in Continuum Mechanics
Ioannis T. Georgiou and Ira B. Schwartz, Organizers

Thursday, May 27

MS50

Invariant Manifolds in Oscillation Problems

10:00 AM-12:00 PM

Room: Wasatch A/B

Invariant Manifolds (center manifolds, hyperbolic manifolds, integral manifolds, etc.) arise naturally in many applied problems such as nonlinear oscillations, communication systems and singular perturbations, in both finite and infinite dimensions. This minisymposium will focus on some recent development of the invariant manifolds theory along with some significant applications to physical problems. By having lectures in different areas of dynamical systems and applications, a primary goal of the minisymposium is to help further research interactions among researchers who are working on fundamental theory of invariant manifolds and applications of invariant manifolds to the qualitative study of differential equations and engineering problems.

Organizer: Yingfei Yi
Georgia Institute of Technology

10:00-10:25 Dynamics of Electronic Oscillators
Michal Odyniec, Hewlett Packard Co.

10:30-10:55 Invariant Manifolds and Foliations for Infinite Dimensional Dynamical Systems
Kening Lu, Brigham Young University

11:00-11:25 Exchange Lemmas for Singularly Perturbed Problems Certain Turning Points
Weishi Liu, University of Missouri, Columbia

11:30-11:55 Singularities of Constrained Differential Systems
Jorge Sotomayor, Universidade de São Paulo, Brasil

Thursday, May 27

MS51

Nonlinear Dynamics in Frontal Polymerization and Combustion

10:00 AM-12:00 PM

Room: Golden Cliff

We consider gaseous and solid fuel combustion as well as exothermic frontal polymerization processes, which are used, in particular, to synthesize materials. Since the structure of the material is determined by the propagation mode of the exothermic wave, various modes must be studied. Analytical, numerical and experimental approaches are employed in a variety of problems, including the dynamics of cellular and hot-spot flames and spinning polymerization modes. Since similar instabilities occur in combustion and polymerization, a joint discussion will be beneficial for researchers in both areas. Thus we want to bring together active researchers with interests in flames, combustion and polymerization waves as well as researchers with interests in nonlinear dynamics in general.

Organizer: Vladimir A. Volpert
Northwestern University

10:00-10:25 Four States of Motion Unique to the Dynamics of Cellular Flames
Michael Gorman, University of Houston

10:30-10:55 Interaction of Counterpropagating Hot Spots in Solid Fuel Combustion
Bernard J. Matkowsky and A. Bayliss, Northwestern University

11:00-11:25 Mathematical Modeling of Frontal Polymerization
Vladimir A. Volpert, Organizer

11:30-11:55 Nonlinear Dynamics in Frontal Polymerization
John A. Pojman, University of Southern Mississippi; and Vitaly Volpert, Université Lyon I, France

Thursday, May 27

MS52

Set-Oriented Methods in the Study of Dynamical Systems

10:00 AM-12:00 PM

Room: Maybird

Nonlinear dynamical systems are often studied by simply computing long trajectories. This minisymposium presents alternative methods based on set-oriented algorithms for the study of invariant manifolds, chaotic and random dynamical systems and experimental data. These methods provide new insights that could not be obtained by long term simulation. They have applications to spacecraft missions, analysis of experimental time series and bifurcations in chaotic or random dynamical systems. Anyone who is frustrated at the lack of information contained in long term simulations should attend this session.

Organizers: Philip J. Aston
University of Surrey, United Kingdom

Michael Dellnitz
Universität Bayreuth, Germany

10:00-10:25 Computation of Lyapunov Exponents via Spatial Integration with Application to Blowout Bifurcations
Philip J. Aston, and Michael Dellnitz, Organizers

10:30-10:55 The Numerical Computation of Rigorous Coverings for Invariant Manifolds
Michael Dellnitz, Organizer, and Oliver Junge, Universität Bayreuth, Germany

11:00-11:25 Symbolic Dynamics for Time Series
Konstantin Mischaikow, Georgia Institute of Technology; M. Mrozek, Uniwersytet Jagiellonski, Krakow, Poland; J. Reiss and A. Szymczak, Georgia Institute of Technology

11:30-11:55 Numerical Approximation of Random Attractors
Hannes Keller and *Günter Ochs,* Universität Bremen, Germany

Thursday, May 27

MS53

Dynamics of Tethered Satellite Systems

10:00 AM-12:00 PM

Room: Superior A

Tethered satellite systems, that is, two or more satellites in orbit connected by thin long cables are a new concept of space exploration with great application potential as has been demonstrated by two NASA Space Shuttle flights. The equations of motion are a set of nonlinear, stiff, coupled partial and ordinary differential equations which pose a number of interesting problems both in their analytical and numerical treatment. The nontrivial mechanical and mathematical modelling of such systems due to their changing mass composition and various aspects concerning the mathematical treatment of the equations of motion, such as the occurrence of chaotic motions; stability of relative equilibria; control strategies of deployment/retrieval of a sub-satellite from a mother-satellite and efficient integration algorithms will be discussed.

Organizer: Hans Troger
Technical University of Vienna, Austria

10:00-10:25 Modelling and Equations of Motion of Tethered Satellite Systems and Some Simulation Results
Hans Troger, Organizer; and Martin Schagerl, Technical University of Vienna, Austria

10:30-10:55 Nonlinear Dynamics of Tethered Satellite Systems
Arun K. Misra and M. S. Nixon, McGill University, Montréal, Canada; and V. J. Modi, University of British Columbia, Vancouver, Canada

11:00-11:25 Relative Equilibria of Tethered Satellite Systems
Martin Krupa, M. Schagerl, A. Steindl, P. Szmolyan, Technical University of Vienna, Austria; and Hans Troger, Organizer

11:30-11:55 Numerical Treatment of the Relative Equilibrium Equations
Alois Steindl, Technical University of Vienna, Austria

Thursday, May 27

MS54

Bifurcation with Euclidean Symmetry

10:00 AM-11:30 AM

Room: Superior B

There have been many recent developments in dynamical systems with Euclidean symmetry (or spatially extended systems), with a wide range of applications including Rayleigh-Bénard convection and Ginzburg-Landau theory, the formation and transitions of spirals in reactive media, and the control of underwater vehicles. The speakers in this minisymposium will provide a survey of several of these developments and applications.

Organizer: Ian Melbourne
University of Houston

10:00-10:25 Validity, Structure and Universality of the Ginzburg-Landau Equations
Ian Melbourne, Organizer

10:30-10:55 Underwater Vehicle Dynamics and Stabilization
Jerrold E. Marsden, California Institute of Technology; Anthony Bloch, University of Michigan, Ann Arbor; and Naomi Ehrich Leonard, Princeton University

11:00-11:25 Bifurcations and Dynamics of Spiral Waves
Björn Sandstede, Ohio State University, Columbus; Arnd Scheel and Claudia Wulff, Freie Universität, Berlin, Germany

Thursday, May 27

MS55

Dynamics and Nonlinear ODEs in Industrial Applications

10:00 AM-12:00 PM

Room: White Pine

The speakers in this minisymposium will discuss problems that arise in industrial applications. The applications are in the telecommunications electronics, and in automotive industries. It is hoped that this session will introduce the audience to the mathematical opportunities in industries.

Organizers: Rachel Kuske and Fadil Santosa
University of Minnesota, Minneapolis

10:00-10:25 Input-Output Modeling of Nonlinear Components
Nicholas B. Tufillaro, Hewlett-Packard Laboratories

10:30-10:55 Nonlinear Control Design for Turbocharged Diesel Engines
Mrdjan Jankovic, Ford Scientific Research Laboratories

11:00-11:25 Theory and Application of Injection Locking
Robert Melville, Bell Laboratories, Lucent Technologies

11:30-11:55 Analyzing Multi-Rate Dynamical Systems Using PDEs
Jaijeet Roychowdhury, Bell Laboratories, Lucent Technologies

Thursday, May 27

IP10

Stability and Instability in Dynamics

12:15 PM-1:15 PM

Room: Ballrooms I, II & III

Chair: Shui-Nee Chow, Georgia Institute of Technology, and University of Singapore

One of the most important problems in Hamiltonian dynamics concerns the stability of near-integrable systems. On one hand, KAM (Kolmogorov-Arnold-Moser) theory states that, in terms of measure, most orbits are stable. On the other hand, one believes that typical high dimensional Hamiltonian systems are topologically unstable, as conjectured by Arnold. The speaker will discuss some of the new methods and results concerning both stability and instability of the Hamiltonian dynamics. In particular, he will discuss the variational method and its applications to Arnold diffusion and various other problems concerning instability.

Zhihong Jeff Xia
Department of Mathematics, Northwestern University

Thursday, May 27

Conference Adjourns

1:15 PM

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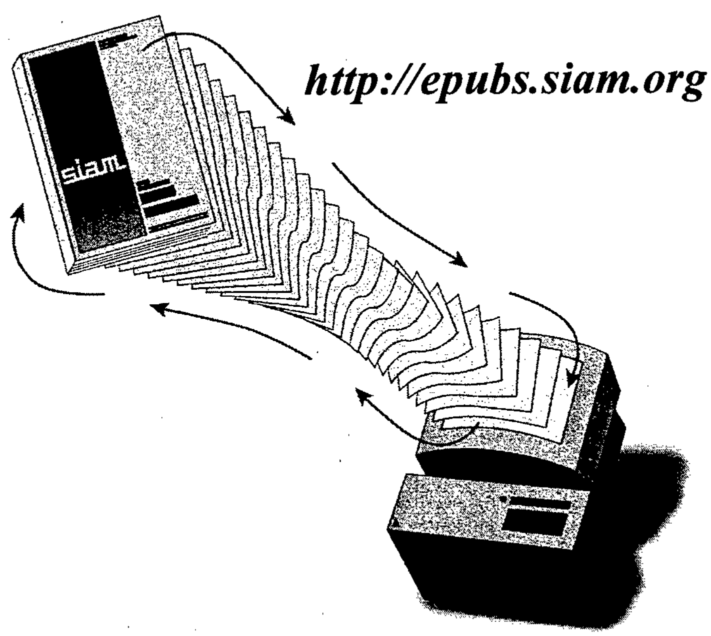

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ABSTRACTS

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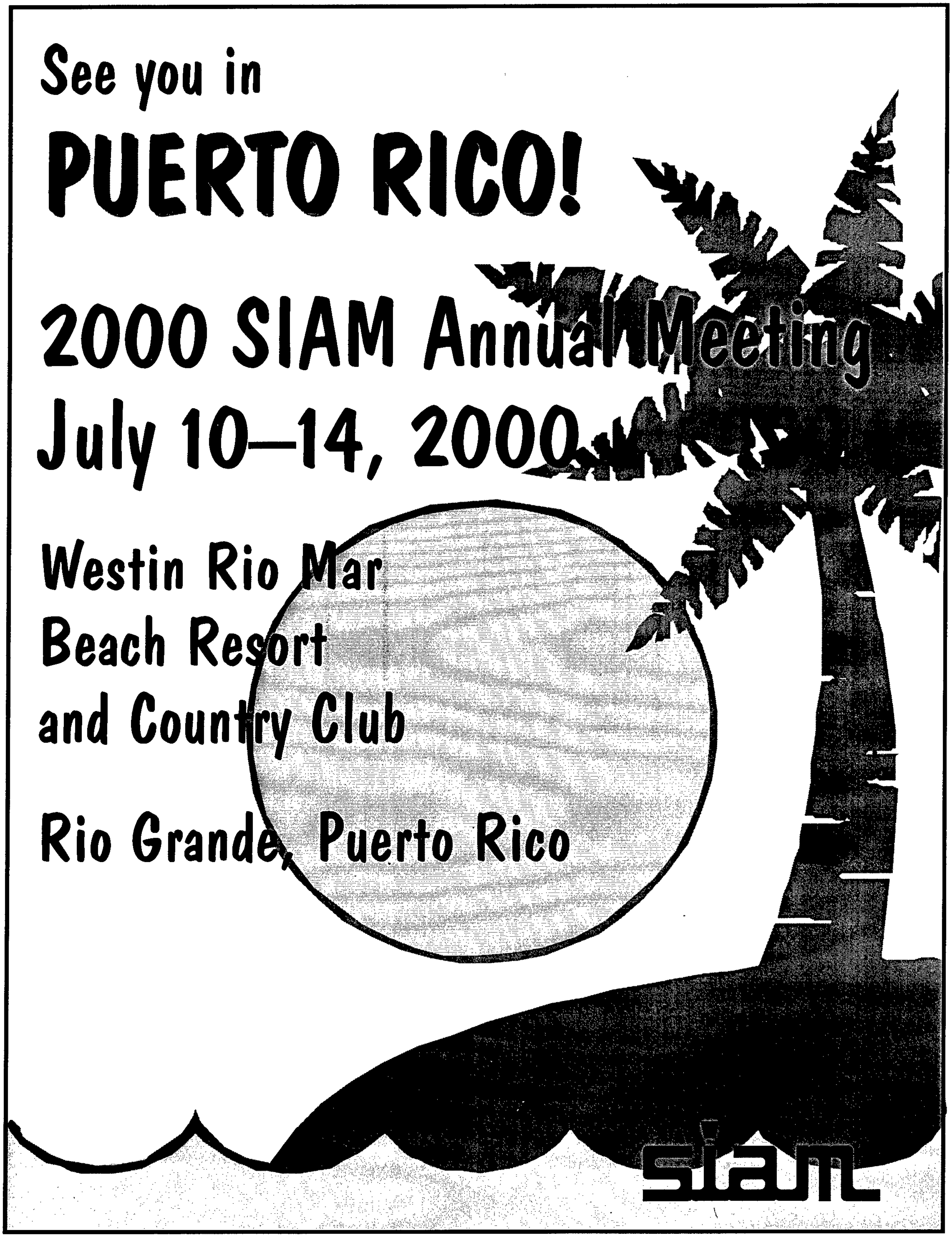
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CP01

A Study of Oscillatory Activity in the Model of the Septo-Hippocampal System

We present an oscillatory model of the septo-hippocampal system with four interactive neural populations (one excitatory and three inhibitory) periodically forced by the entorhinal cortex. Using bifurcation analysis we found dynamical modes with fast (40 Hz, gamma-rhythm) and slow (5 Hz, theta-rhythm) oscillations. These results are in a good agreement with experimental evidence on septo-hippocampal dynamics both in normal conditions and under different lesions. We discuss applications of this model for memory and learning.

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CP01

Dimension Estimation for Seizure Prediction and Localization

By comparing several methods for estimating the dimension of time series from electroencephalograms (EEG) of patients obtained during presurgical evaluation for intractable epilepsy, we were able to develop a composite approach which proved to predict seizure onset time and location with greater accuracy than previously-applied algorithms.

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CP01

Rate-Dependent Activity in Excitable Cells

We analyze a model of spontaneous secondary spike initiation in a neuron. The mechanism of spontaneous spike generation is analogous to that causing the repetitive activity in squid axon due to an applied current. A combination of bifurcation analysis and numerical computations indicates that spontaneous secondary spikes occur when a particular parameter rests near a saddle-node of periodics bifurcation point. A similar analysis suggests why certain experimental interventions promote triggered activity in cardiac cells.

Jennifer S. Enns-Ruttan and Robert M. Miura
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CP01

Understanding Interspike Interval Variability

In the past investigators have shown that a constant current injected into a neuron results in a highly variable response, while injection of a variable (i.e. random) current results in a more reliable response. We supply evidence that this phenomenon is dependent upon the previous history of the neurons. By setting the membrane potential history we can account for significant features in the variability of the response.

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CP01

Synchronous Behavior of Two Coupled Biological Neurons

We report experimental studies of synchronization phenomena in a pair of biological neurons that interact through naturally occurring, electrical coupling. When these neurons generate irregular bursts of spikes, the natural coupling synchronizes slow oscillations of membrane potential, but not the fast spikes. By adding artificial electrical coupling we studied transitions between synchrony and asynchrony in both slow oscillations and fast spikes. We discuss the dynamics of bursting and synchronization in living neurons.

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CP01

Genesis of Coherent Structures in a Discrete Chaotic Neural Medium

We disclose the origin of large scale coherent structures in a discrete nonequilibrium medium of locally interacting chaotic neurons with fast and slow oscillations. Introducing the concept of 'coarse grain' as a cluster of neurons with periodic averaged behavior allows consideration of the dynamics of a new medium composed of these clusters. Ordered, quasi-steady, large scale patterns are revealed in the slow dynamics controlled by the average intensity of the chaotic rapid pulsation.

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CP02

Connecting Double Points in Rayleigh-Bénard Convection

We consider steady, 2-D, viscous incompressible flow between parallel plates, the bottom of which is heated (Rayleigh-Bénard convection), and periodic in the other direction. Using two-parameter pseudo-arclength continuation, we compute the bifurcation diagram in the (period, Rayleigh number) plane in the neighborhoods of the crossings (double points) of several pairs of neutral stability curves. We discover several secondary bifurcation paths connecting pairs of these crossings.

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CP02

Laminar and Turbulent Energy Dissipation in a Shear Boundary Layer with Suction

The rate of viscous energy dissipation in a shear layer of incompressible Newtonian fluid with injection and suction is studied by means of exact solutions, nonlinear and linearized stability theory, and rigorous upper bounds. We find that the upper bound on the energy dissipation rate, valid even for turbulent solutions of the Navier-Stokes equations, scales precisely the same as that in the laminar exact solution with regard to the viscosity as $\nu \to 0$.

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CP02

Time-Dependent Flow Regimes in Two-Phase Flows and Compressible Fluids

Traveling waves (of voidage) are observed to move through fluidized gas-particle suspensions (fluidized beds) as well as other two-phase flows. In order to gain an understanding of the mechanics of such voidage waves, a bifurcation analysis has been used to capture the evolution of instabilities in a compressible fluid which is acted upon by a density dependent force. These instabilities take the form of density waves which resemble the voidage waves in fluidized beds.

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CP02

Spatial and Temporal Resonances in a Periodically Forced Extended System

The occurrence of a Naimark–Sacker bifurcation in a periodically forced spatially extended system is analyzed with Floquet theory. Windows in parameter space where onset of instability is via Naimark–Sacker correspond to forcing frequencies close to the natural frequencies of the unforced system when the forcing amplitude is sufficiently large. In these windows, not only have strong temporal resonances been identified, but also competition and resonances between various spatial modes that are simultaneously excited take place. An excitation diagram mapping out these windows and loci of resonance points is produced, providing a guide for future explorations into the nonlinear regime by either experimental or computational techniques.

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CP02

Stability Analysis of Perturbed Plane Couette Flow

Plane Couette flow is linearly stable at all Reynolds numbers, but undergoes sudden transition to turbulence experimentally and numerically near Re=300. Searching for intermediate states by inserting a wire into the flow, experimentalists observe 3D steady states containing streamwise vortices. Using a spectral-element code, we show that these states arise via subcritical pitchfork bifurcation. We investigate the transition to time-dependence, and the dependence of the scenario on wire radius.

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CP02

Asymptotic Regime of the Rayleigh-Taylor Instability in the large-time Limit

We propose a variational method for the description of the asymptotic regime of the Rayleigh-Taylor instability when $t \to \infty$. To describe the dynamics of a highly curved interface, we use a time dependent conformal mapping. In the simplest case, when there is a single symmetric finger, we obtain a simple integrable Hamiltonian system. We discuss its solution and physical implication.

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CP03

Chaos Communications Using Virtual Synchronization

Virtual synchronization is presented as a new technique for practical communication using chaotic waveforms. Compared to methods using conventional synchronization, virtual synchronization does not require strict correlation of system states; rather, it requires that only limited characteristics of the source system are matched by the response system. As a result, communication with virtual synchronization is more tolerant to channel noise, narrowband interference, signal fading, and bandwidth limiting than other synchronization-based techniques.

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CP03

Theory of Wavelength Division Multiplexing in Fiber Links with Dispersion Management

Wavelength Division Multiplexing (WDM) is an important technique used in modern optical fiber telecommunications. This technique consists of dividing the window of a fiber's optical transparency into several frequency channels, and transmitting the information through all channels in parallel. We will present an introduction to the theory of soliton communications for WDM and a rewiew of experimental results. The physical limitations, such as four-wave mixing due to interchannel interaction and polarization mode dispersion, will also be explained. We will discuss several aspects of WDM including dispersion management and distributed amplification for high bit-rate optical data transmission. In many cases, WDM data transmission can be described in terms of a system of coupled nonlinear Schroedenger equations. We will present a mathematical approach for finding analytical solutions of such systems.

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CP03

Polarization-Based Laser Communication Schemes

Laser-based chaotic communication has recently been demonstrated using pairs of erbium-doped fiber-ring lasers. Such lasers exhibit dynamics which involve both polarization states of light in a fundamental way. We consider a simplified laser model based on vector Maxwell-Bloch equations and explore the dynamics for different couplings between the fundamental polarization modes. In particular, we analyze message security using various communication schemes. We also comment on results based on actual experimental data.

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CP03

Multiple-Scale Averaging and Optimization of Amplifier Placement in Multi-Channel Dispersion-Managed Soliton Transmission

We analyze the nonlinear Schrödinger equation using multiple-scale averaging to investigate a simple design of two-step dispersion maps that are advantageous for wavelength-division-multiplexing. We show that for any ratio of the lengths of the fiber segments comprising a map, one can obtain a choice of amplifier placement that allows simultaneous minimization of dispersive radiation in several different channels. We also investigate the effect of the amplifier placement on the power enhancement of the dispersion-managed soliton.

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CP03

Premature Synchronisation in Coupled Maps

Recently, there has been immense interest in the phenomenon of synchronization of coupled oscillators. The stability of an invariant state in the coupled systems is determined by the sign of the largest transverse Lyapunov exponent, a quantity which frequently decreases with increasing coupling strength, until stability is obtained. In this paper, we report simple cases in which analytic representations of the threshold stability coupling strength are obtainable, but are not in agreement with numerics. This phenomenon is discretization induced, and is well explained by the use of cell-mapping techniques.

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CP03

Security Issues in Chaotic Communications

We consider security in new chaotic communications techniques. Hybrid techniques using encryption and chaotic communication are considered, and we show circumstances under which it is possible to extract the hidden signals. We introduce a new technique which employs a digital (control/no control) link between chaotic transmitter and receiver, where remote initialization is possible, but the transmitted information is independent of the state of the chaos, so unmasking by nonlinear dynamic forecasting fails completely.

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CP04

Singular Poincaré-Andronov-Hopf Bifurcation to Relaxation Oscillations During High-Speed Metal Cutting

We have developed a new model for chip formation in high-speed machining that is similar to models of open chemical reactors. We show that, as the tool cutting speed is increased, a singular Poincaré-Andronov-Hopf bifurcation occurs in the model. This provides an explanation for the change from continuous to segmented chip formation that is observed in most metals as cutting speed increases.

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CP04

Symmetry-Breaking Bifurcations in a Hopf/Steady-State Mode Interaction in Three-Dimensional Magnetoconvection

Mode interactions in 3D convection have received little attention, despite their physical relevance. In magnetoconvection we can find a point where the conduction state is unstable to both steady and oscillatory motion simultaneously and it is possible to apply weakly nonlinear theory. Physical symmetries play a large role in determining the bifurcation structure and explain the appearance of interesting phenomena like drifting solutions. Weakly nonlinear analysis elucidates the complex transition between steady and oscillatory convection.

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CP04

Double Hopf Bifurcation in a Geophysical Fluid Dynamics Model

We show, using center manifold reduction, that in a model of large scale atmospheric flow double Hopf bifurcations lead to two simultaneously stable periodic solutions (two travelling waves with different wave numbers) in the geophysically relevant range of parameters. The results, which are observed for several pairs of wave numbers, indicate hysteresis of the wave solutions. The eigenfunctions of the model cannot be found analytically and therefore they must be found numerically. This leads to numerical approximations of the normal form coefficients.

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CP04

Thermo-Acoustic Instabilities in Aeropropulsion Systems

Lean premixed combustors are inherently susceptible to thermo-acoustic instabilities, in which the interaction be-

tween the chemical kinetics and the underlying fluid flow serves to excite an acoustic response within the enclosed volume of the combustor. This problem is studied with the goal of obtaining reduced-order dynamical models which capture the self-excited oscillations seen in real gas turbine systems. A linear analysis is used to describe the stability of the time-independent solution, while asymptotic methods are employed to decouple the reaction-diffusion equations governing the transport and combustion of the reactant from the equations governing the fluid flow.

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CP04

Visual Interpretation of Transitions in Spatiotemporal Systems

Empirical analysis of bifurcations in simulations and laboratory experiments requires the comparison of spatiotemporal data sets acquired at several parameter values near the transition point. This paper develops visual techniques for comparing such spatiotemporal collections based on three general approaches: visual tiling, summary extraction and abstraction, and projection on a common coordinate system. The techniques are illustrated by an analysis of video data from an experimental survey in a combustion experiment near the extinction boundary.

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CP05

A Model of Central Pattern Generators for Quadruped Locomotion

It is known that gaits of quadrupeds are periodic and symmetric motions. We model the Central Pattern Generators (CPGs) for quadruped locomotion using coupled cell systems (cell=ODE). Our approach uses equivariant bifurcation theory. We present a network of symmetrically coupled cells modeling the CPG for locomotion of quadrupeds. The network produces periodic solutions with phase shifts of common quadruped gaits. We show that bifurcations from the periodic solutions lead to periodic solutions of gaits adopted at higher speeds. We discuss the stability of the periodic solutions and show that our network model is the simplest one under certain modeling assumptions.

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CP05

Normal Forms via Non-Normal Means

Normal forms have proven to be a powerful tool for investigating the bifurcation structure of nonlinear dynamical systems. There exists a standard procedure on the space of vector valued monomials for systematically removing nonlinear terms from the original dynamical system. However, the procedure has no convergence guarantees and often produces systems with discouragingly small regions of validity. We present a generalization of the technique on a different space with much improved results.

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CP05

Heteroclinic Cycles in Networks of Cells with $\mathbf{D_n}$–Symmetry

In this work, we investigate the existence and stability of intermittent cycles involving steady states and periodic solutions in networks of coupled cells with $\mathbf{D_n}$-symmetry. Based on the lattice of isotropy subgroups, we study the vector field restricted to invariant fixed-point subspaces. When certain conditions are satisfied, we prove that it is possible to have asymptotically stable cycles connecting periodic solutions with steady states and periodic solutions with periodic solutions.

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CP05

Chaotic Direction-Reversing Waves

Secondary bifurcations in systems with O(2) symmetry are studied with emphasis on different codimension one mechanisms generating nonlinear waves that reverse their direction of propagation in a chaotic fashion. The mechanisms are illustrated using the normal form for the triple zero bifurcation with O(2) symmetry and involve parity-breaking bifurcations of standing waves or global connections involving circles of standing waves and/or steady states. Applications to fluid convection are described.

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CP05

Bursts in Oscillatory Systems with Broken D_4 Symmetry

A new mechanism responsible for generating regular and irregular bursts of large dynamic range near onset of an oscillatory instability is identified. The bursts are present in systems with nearly square symmetry and are the result of global connections involving infinite amplitude states created when the square symmetry is broken. The intricate sequence of bifurcations that take place is described in several cases, and the possible relevance of the results to experiments is discussed.

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CP05

Doubly Forced Oscillators

We consider models of doubly forced planar oscillators of the form:

$$\dot{x} = F(x) + \alpha\{(1-\gamma)G_1(x, n\omega t) + \gamma G_2(x, m\omega t)\}.$$

The forcing frequency ω and forcing amplitude α are primary parameters; γ, controlling the relative amplitudes of forcing, is an auxiliary parameter. Perturbing γ from zero or one results in symmetry breaking of a Hopf bifurcation. Running γ between zero and one "melts" a period-q_1 resonance region (Arnold horn) into a period-q_2 region and provides a natural example of "Arnold flames."

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CP06

Dynamics of Low-Amplitude Resonant Light-Matter Interaction

The ideal Maxwell-Bloch equations describe lossless, resonant interaction of light with a two-level optical medium. With the medium in the ground state, expanding about a harmonic pulse with a small, slowly-varying amplitude yields a nonlinear Schrodinger-type equation for the electric field envelope. Expansions are performed on the Lax pair as well as the equations to ensure integrability is retained. Dynamics of the solutions in this limit are compared analytically and numerically.

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CP06

Bi-Instability and Ultrasubharmonics in a Modulated Laser

Bi-instability, in contrast of bistability, is shown to generate unstable chaotic saddles prior to chaos in a laser with modulated losses. Theory and numerics are used to show that: (i) Unstable saddles form heteroclinic connections that allow mixing between chaotic attractors to produce mixed-mode chaos. (ii) Ultrasubharmonic orbits can generate long-period but low-amplitude laser response.

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CP06

Dynamics of Wavelength-Division-Multiplexed Transmission of Return-to-Zero Pulses in Dispersion-Managed Optical Fibers

We analyze wavelength-division-multiplexed transmission of return-to-zero pulses in a dispersion-managed optical fiber. An accurate ODE model for the pulse dynamics is constructed and integrated analytically for piecewise-constant dispersion maps. The analytic theory enables one to efficiently evaluate the performance of various system arrangements. An optimized system design is then identified, which produces unchirped output pulses across a practical wavelength range without the need for channel-by-channel fine-tuning.

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CP06

Self-Pulsations of a Lasers with Saturable Absorber

We consider the three-dimensional Yamada system, a simple model for self-pulsations in (semiconductor) lasers with

saturable absorber. By identifying a Bogdanov-Takens bifurcation as an organizing center we show that pulses are created in a homoclinic bifurcation, as was conjectured in earlier work. For realistic values of the parameters this homoclinic bifurcation practically coincides with the laser reaching its threshold, which explains why it was not found earlier.

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CP06

Controlling Resonant Wave Interactions to Enhance Frequency Conversion in Nonlinear Optics

Efficient frequency conversion of light waves is realized in nonlinear optics using piece-wise constant controls. The N-wave equations model this process. A convenient setting in which to analyze their control is obtained using Poisson reduction. Symmetries that produce phase shifts are factored out and the amplitude dynamics are projected onto a reduced phase space. In this geometrical setting controls for four-wave and multiply-resonant quadratic interactions are obtained.

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CP06

Estimating Parameters in Laser Dynamics

In nonlinear optics, comparison between experiment and theory is usually performed qualitatively by visually comparing measured data to simulations of the corresponding differential equations. It can not be decided whether possible discrepancies are due to wrongly chosen parameters in correct models or whether it is the models themselves which are actually incorrect. We show that the parameters of the differential equations can be estimated from the data and that models can be compared statistically.

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CP07

Homoclinic and Heteroclinic Orbits for Singularly Perturbed nearly Integrable Systems

We study nearly integrable 3-dimensional systems devised by Doelman and Hek based on the complex Ginzburg-Landau equation. Solutions of interest for this system are single and multiple pulse homoclinic and heteroclinic orbits which correspond to traveling localized structures in the Ginzburg-Landau equation. Using geometrical singular perturbation arguments, Doelman and Hek proved that for each integer $N \leq O(|\ln \epsilon|)$ there are two N-pulse orbits. We use shooting arguments to improve their estimate to $N \leq O(1/\epsilon)$.

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CP07

Homoclinic Bifurcations and Chaos in the Presence of a Center Manifold

We consider differential equations consisting of hyperbolic and center parts and use our previous generalized Melnikov theory to find a transverse homoclinic orbit for the hyperbolic part. We construct a topological conjugacy between a multiple of the period map for the hyperbolic flow and the Bernoulli shift through Palmer's construction which uses chaotic jumping solutions. With damping and applied forcing the center part becomes weakly attracting and with this we can shadow Palmer's jumping s olutions extending the topological conjugacy to the full equation. The theory is applied to vibrating elastic beams.

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CP07

Slow Passage Through a Saddle-Center Bifurcation

Slowly varying potentials are analyzed. Away from homoclinic orbits, strongly nonlinear oscillations are obtained using the method of averaging. For a saddle-center bifurcation, solutions consist of a large sequence of nearly saddle-center homoclinic orbits connecting autonomous nonlinear saddle approaches, and the change in the action is determined. However, a saddle approach with particularly small energy is nonautonomous, and may also provide a transition to small oscillations around the center.

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CP07

Homoclinic and Heteroclinic Orbits in Cylinder Buckling

We investigate the post-buckling regime of a cylindrical shell this exhibits an initially unstable response that then restabilizes with the formation of localized buckles in a cell.

As buckling continues over a growing number of cells the response can be described by a set homoclinic connections. In the limit, this leads to a heteroclinic connection from the fundamental unbuckled state to a post buckled state that is periodic. We describe this phenomena and present some numerical results.

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CP07

Heteroclinic Bifurcations as the onset of Voltage Collapse in a Power System Model

We investigate a widely used four-dimensional power system model exhibiting voltage collapse. With the reactive power demand as a bifurcation parameter, we find a heteroclinic bifurcation between the one-dimensional unstable manifold of a saddle equilibrium and the three-dimensional stable manifold of a saddle periodic orbit. This results in severe shrinking of the basin of attraction of the operating point. We believe that here lies the onset of voltage collape and illustrate our findings with numerical computations.

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CP07

Homoclinic and Heteroclinic Motions for Resonant Periodic Orbits in Forced, Two-Degree-of-Freedom Systems

We study homoclinic and heteroclinic motions in periodic perturbations of two-degree-of-freedom Hamiltonian systems having a saddle-center with a homoclinic orbit. We assume that the primary resonance occurs near the unperturbed saddle-center and apply a Melnikov-type approach and the averaging method to obtain criteria for the existence of transverse homoclinic and heteroclinic orbits to periodic orbits near the saddle-center. To illustrate the theory we give an example for the forced, coupled Duffing oscillators.

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CP08

Propagation of Phase Transformation Front In 1D Shape Memory Allow Induced by Impact Loading

We study phase transformation propagation in quasi-1D semi-infinite SMA rod in the framework of constitutive theory due to Bekker/Brinson and Boyd/Bo/Lagoudas. This theory with martensite fraction serving as internal variable was developed for SMA materials with transformation hardening behavior (monotone nonconvex stress-strain relation. First we study impact problem in isothermal setting, that provides an important insight on the structure of the solution, and then adiabatic-isoentropic approximation is used to find shock adiabat-isoentrope of 1D SMA body with linear kinetics. Numerical results obtained for the full system of equations are in excellent agreement with analytical results for adiabatic-isoentropic model. The nonuniqueness issue inherent to wave propagation problems in SMA materials due to nonconvex constitutive law is thoroughly discussed.

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CP08

Critical States and Minima for an Energy with Second Order Gradients

Coleman, Marcus & Mizel [1992] studied the thermodynamical equilibrium of second-order materials and showed that in certain regimes such materials must exhibit equilibrium states that are nonuniform by proving that space-periodic solutions can have lower energy than space-uniform ones. A dynamical systems approach is used here and it is shown that there is a critical value of the mean concentration. When the mean concentration crosses this critical value, the uniform state can lose its minimizing character and periodic or quasiperiodic states can have lower energy. The presence of that critical value corresponds to a 1:1 resonance.

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CP08

An Integrodifferential Model of Phase Separation

In this talk we shall consider two aspects of the order parameter non-preserving model of phase separation based on the Khachaturyan free-energy functional in a finite domain

$\Omega \subset \mathbf{R}^n$, namely,

$$u_t = \epsilon \int_\Omega J(|x-y|)(u(y)-u(x))\,dx - f(u),$$

where $f(u)$ is bistable. We discuss the behaviour of the dynamical system generated by the above equation, in particular the existence and structure of a compact attractor and display numerical experiments of coarsening in this system which is very different from that of the Allen-Cahn equation.

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CP08

Disjoining Potential and Spreading of Thin Liquid Layers in the Diffuse Interface Model Coupled to Hydrodynamics

The hydrodynamic phase field model is applied to the problem of film spreading on a solid surface. The disjoining potential, responsible for modification of the fluid properties near a three-phase contact line, is computed from the solvability conditions of the density field equation with appropriate boundary conditions imposed on the solid support. The equation describing the motion of a spreading film are derived in the lubrication approximation. In the case of quasi-equilibrium spreading, is shown that the correct sharp-interface limit is obtained, and sample solutions are obtained by numerical integration. It is further shown that evaporation or condensation may strongly affect the dynamics near the contact line, and accounting for kinetic retardation of the interphase transport is necessary to build up a consistent theory.

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CP08

Nucleation Dynamics of Cahn-Hilliard Equation

We discuss the nucleation dynamics of Cahn-Hilliard equation, a widely accepted model for some complicated behavior of the concentration of a binary alloy. Precise information on the spike-like steady state solutions and estimates on associated eigenvalue problems will be given

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CP09

Intermittent Phase Transitions in a Two-Dimensional Stick-Slip Model of Eartquakes

Stick-slip behavior of a spring-block oscillator in two dimensions is studied. The comparison to the case of one-dimensional stick-slip reveals intrinsic differences of the present model, consisting in the necessity to use a modified friction-velocity relation, and emergence of intermittent switching between creep and slip phases of motion. The principal role of asymmetric elastic forces is investigated, and the necessary conditions for the existence of itermittency are obtained. The prospects of the model for the problem of earthquake prediction are discussed.

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CP09

Dynamics and Control of a Constrained Impact Oscillator

We model a feedback-assisted actuator as an impact oscillator constrained between two parallel walls. The dynamical behaviour, seen as a Poincaré map, is compared to a stroboscopic data set obtained from an experimental model. Whereas some topological features correspond to undesirable impacting behaviour, in other cases periodic impacts may be a required feature of engineering applications. We analyze the stability of some orbits, and finally we apply OGY control algorithms on the impact map.

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CP09

Asymptotic Behavior in a Two Degree of Freedom Mechanical System with a Stop

We study the dynamics of a two degree of freedom, piecewise linear, frictionless, unforced, mechanical system constrained by stops. The system is governed by three types of dynamics: coupled harmonic oscillation, simple harmonic motion and discrete rebounds. Energy is dissipated discon-

tinuously in discrete amounts, through impacts with the stops. This dissipation mechanism, coupled with the qualitatively different behaviors allowed by the hybrid dynamics, results in a rich global limiting asymptotic behavior which we characterize.

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CP10

Low-Dimensional Atmospheric Models at Various Truncations

By making use of empirical orthogonal functions (EOFs) and experimental corrections, an atmospheric model is obtained that can be truncated at arbitrary low dimensions and behaves quite realistically above approximately 30 dimensions. Results will be presented of an investigation into the dependence of the dynamical properties on the model truncation, using bifurcation analysis. The convergence of the bifurcation diagram and robustness of certain dynamical characteristics above 30 dimensions are key issues of this investigation.

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CP10

Finite Difference Balance Models

We study numerical solutions of the reduced-gravity shallow-water equation on a beta plane, subjected to a sinusoidally varying wind forcing leading to the formation of a double gyre circulation. A method is presented, applicable to any finite-difference scheme, that effectively increases the spatial resolution of the given algorithm without changing its temporal stability or memory requirements. This *enslaving* method makes use of the gestrophic balance of the flow to reduce the overall truncation error. By examining statistical measures of stochastic solutions, we show that the enslaved schemes are capable of reproducing statistics of standard schemes computed at twice the resolution.

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CP10

Global Bifurcation in a Simple Ocean Model

We demonstrate the existence of a global bifurcation sequence in a simple ocean model, the equivalent barotropic quasi-geostrophic model. All previous studies of this model in the context of single and double gyre circulations have demonstrated various bifurcations, but all of which are local in nature. The complicated bifurcation sequence that we demonstrate is sometimes called the Shilnikov phenomenon and involves a somewhat novel applications of power spectra and proper orthogonal decomposition techniques.

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CP10

Reversals and on-off Intermittency in the Dynamics of the Convective Dynamo

The nature of the dynamo action is investigated in a kinematic dynamo forced by heteroclinic and chaotic convective velocity fields resulting from a bifurcation analysis of the spherical Benard problem. Reversals of poles, chaotic and on-off intermittent behavior of the magnetic field are obtained. The relevance of this form of intermittency to the dynamics of sunspots is discussed. An antidynamo conjecture suggested by the numerical experiment is analyzed.

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CP10

A Low-Dimensional Climate Model II

A five dimensional model is studied which combines the Lorenz-84 model for the atmosphere, and Stommel's 2-box model for the ocean. The time scales of these models are very much different. Varying the coupling parameters, regular as well as chaotic behaviour is found. In the transition to chaos intermittency is observed. This is explained by means of bifurcation and stability analysis. The slow dynamics of the ocean model plays an essential role.

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CP10

A Low-Dimensional Climate Model I

We present a low-dimensional ocean-atmosphere system based on coupling of the atmospheric Lorenz-84 model and Stommel's 2-box ocean model. The coupling involves heat and water/vapour transport. One of the intriguing problems of this system is the part played by the very different time- scales of its components. We discuss some aspects of the bifurcations and the presence of intermittency.

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CP11
A Kinetic Model for Granular Media

We present a kinetic model for granular media. The model incorporates all the effects of inelasticity, rotational freedom and volume-exclusion. Both asymptotic solution and numerical simulation of the model show that the volume-exclusion has a siginificant effect on the energy distribution between rotational and translational motions. Such an effect has been ignored in the literature. The evolution of the statistical quantities exibits interesting features with the variation of inelasticity.

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CP11
Molecular Dynamic Simulations of Clusters in Sheared Granular Materials

A molecular dynamic simulation has been used to examine the effect of cluster formation on stress and other macroscopic quantities in a rapidly sheared granular material. The shear flow evolves to a dynamic system of clusters, which form and break up as time progresses. It is observed that the stress increases with the degree of clustering and there is weak scale separation between the microscopic and macroscopic scales.

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CP11
About Motion of Spherical Particles on a Surface

Using theoretical analysis and molecular dynamics simulations, we explore 2D system of spherical particles. Paying particular attention to the modeling of the frictional interaction of the particles with the substrate, we discuss transfer of energy from the particles to the substrate and possibility of formulation of a continuum theory. We observe that, due to this frictional interaction, the inelastic collapse is not observed.

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CP11
Spontaneous Chaotic Granular Mixing

Instabilities leading to spontaneous chaotic mixing have a rich history in fluid mechanics. By contrast, in granular flows mixing is believed to be diffusive, and spontaneous chaotic behavior has not previously been reported. In the presence of stick-slip motion, however, we find the spontaneous emergence of intricate mixing patterns which we duplicate in an explicit continuum model. Both model and experiment produce exponentially rapid, chaotic, mixing.

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CP12
Dynamics of Human Blood Distribution System

We demonstrate that five almost periodic processes are mutually coupled to govern the dynamics of blood distribution in humans. Using wavelet transform, four characteristic peaks with slowly varying amplitudes and frequencies were found in the heart rate variability on the time scale of blood distributive processes. Peaks at almost the same frequencies were also found in blood flow, pressure and respiratory signals, together with the fifth peak at the heart rate. We discuss changes in the frequency content in some cardiovascular diseases.

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CP12
Modelling the Control of Ovulation in Terms of Gonadotropin Receptors in Granulosa Cells

The primary mechanism controlling ovulation in primates is believed to rely on a competitive process between a group of developing follicles. Such competition is mediated through a hormonal feedback loop involving the pituitary gland. However, little is known about how these follicles react to the pituitary hormones. We present an ordinary differential equation model which explicitly describes follicular sensitivity to gonadotropins in terms of the equilibrium concentration of bound receptors in the granulosa cells.

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CP12

Respiration by Turbulant Diffusion in Frogs

A turbulant diffusion column ventilates the lungs of resting frogs of several species, whereby throat movements (gular undulations) exchange gas in the buccal cavity with ambient air through open nares and with pulmonary gas through an open glottis. Oxygen and carbon dioxide diffuse along respective concentration gradients. Gular undulations contribute turbulance to the diffusion producing a space time fractal. A model using inhaled tantalum particles permits visualization of random walk trajectories leading to turbulant flows.

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CP12

The Mechanics of Lung Tissue Under High-Frequency Lung Ventilation

High frequency lung ventilation has been shown to benefit patients with severe respiratory distress, but may also induce lung damage, and a clear protocol for the most effective treatment has not been identified. We use a homogenisation theory approach to derive equations for the macroscopic behaviour of lung tissue based upon the microstructure of respiratory regions. This, in combination with larger scale numerical simulations, forms the first step towards a predictive model to aid clinical decision making.

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CP12

Cardiorespiratory Interaction in Anesthesia

The cardiac and respiratory systems are known to be oscillatory and mutually coupled; their coupling is manifested in the heart rate variability (HRV). Using the time-frequency analysis we show that in anesthetized rats the energy of the HRV is significantly reduced. Additionally, $n:m$ frequency synchronization, but no single phase locking between heartbeat and respiration were observed. The depth of anesthesia can be characterized by the frequency ratio of those two coupled oscillators, as well as by the extent of the HRV.

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CP12

Subcellular Mechanisms for the Regularization of Neural Bursting Activity

An essential question raised after the observation of highly variable bursting activity in individual neurons of central pattern generators is how an assembly of such neurons can cooperatively produce regular signals to motor systems. Periodic driving or mutual inhibitory connectivity are mechanisms that regulate this behavior. We discuss how slow subcellular dynamics such as luminal calcium oscillations may play an important role in the genesis and regularization of the chaotic activity observed in the experiments.

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CP13

The Contraction of the Asymptotic Solutions of the System of Differential Equations with Deviating Argument

The Constraction of the Asymptotic Solutions of The system of differential equation with deviating argument. The communication deals with the initial-value problem for the system of linear differential equations with slowly varying coefficients and with lagging argument.

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CP13

Delay-Differential Equations with a Large Delay: Application to Semiconductor Laser Instabilities

Semiconductor lasers have a lot of applications but are extremely sensitive to optical feedback. The problem is modeled mathematically by delay-differential equations where the delay is large compared to the laser time constants. This motivates the study of system of delay-differential equations exhibiting a weak feedback but a strong delay. We show that this delay leads to multiple branching of peri-

odic solutions as well as secondary bifurcation to quasiperiodic oscillations.

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CP13

Numerical Methods for Delay Differential Equations: New Approach, Software Package, Applications

We present an approach to constructing of numerical methods for Delay Differential Equations. The approach is based on the constructions of a new i-smooth calculus of nonlinear functionals. On the basis of this approach the Time-Delay System Toolbox is elaborated. Applications of the Toolbox for simulating and analysis of specific time-delay models are discussed.

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CP13

Existence of Periodic Solutions for a State Dependent Delay Differential Equation

We present a model of population dynamic with provide a state dependent delay equation. We then consider the problem of finding non trivial periodic solutions for this state dependent delay differential equation. The equation was introduced by Arino, Hadeler, Hbid (1998). In this work we prove the existence of slowly oscillating periodic solutions, by using a new approach.

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CP13

On the Stability of Neutral Functional Differential Equations

This talk concerns the behaviour of the essential spectrum of neutral functional differential equations. We emphasize on limit cases whereby some of the delays are brought to zero or asymptotically coincide, which may lead to eigenvalues moving to infinity. Necessary and sufficient conditions are provided. Thereby the ratio of the delays plays a crucial role. The theory can be applied to analyze the robustness of boundary controlled PDEs in the presence of small feedback delays, as will be illustrated by examples.

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CP14

Vanishing Twist near Resonances in Symplectic Maps

Using normal forms we show that in the neighborhood of an elliptic point of an area preserving map with multiplier a third root of unity the twist vanishes. As a corollary if follows that the collision of Poincare-Birkhoff island chains with the same winding number close to a twist-less curve is generic in area preserving maps. The same phenomenon is analyzed in a four dimensional symplectic map, where also another low order resonance makes the twist vanish close by.

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CP14

Volume-Preserving Reduction by Symmetry

Reduction by symmetry of N-dimensional volume-preserving dynamical systems admitting volume-preserving symmetries is discussed, extending previous theories for three-dimensional systems.

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CP14

Size Matters in Small One-Dimensional Lattices

We examine how the well-known continuum scaling of a chain with nonlinear nearest-neighbor interactions falters and then fails. As the system size shrinks, continuum behavior yields to a discrete regime which is explicitly size dependent. The transition between regimes occurs at a critical value of system size that coincides with the onset of instability. The parity of the inter-particle potential strongly influences the transition to the small-chain limit.

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CP14

Quadratic Volume Preserving Maps: Normal Forms and Dynamics

We consider quadratic, volume preserving maps that have a quadratic inverse. In R^3 the normal form for these maps has a simple, Hénon-like form $(x, y, z) \rightarrow (\alpha+\tau x+z+ax^2+bxy+cy^2, x, y)$. We discuss the bifurcations of curves of heteroclinic orbits, defining the primary intersection curves. We relate these to a codimension-one Melnikov function. Numerical experiments will be shown.

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CP14

Properties of Integrability of Systems in Terms of Transcendental Functions

Concept of integrability in the class of transcendental functions arises for the reason of availability of this system of asymptotic (attracting or repelling) limited sets, i.e. sets that have the neighborhood which consist of diversities of dimension above 1. Let's remark, that in the spaces of dimension higher than 2 it is eliminated even case of a rough saddle as those can exist whole diversities of a codimension 1 attracted or repelled to the saddle.

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CP14

Stability Exponents and Separation of Variables

The problem of defining self-consistent local and global stability exponents is identical to the problem of separation of variables. Near an equilibrium point we show that separation of variables can be performed as a natural extension of the familiar linear system. As in central manifold theory, the decomposition fails for Hamiltonian systems. We explore different options for defining the stability exponents, and the extent of invariance to the initial reference frame choice.

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CP15

Identification and Characterization of High-Dimensional Chaos

The restriction of nonlinear time series analysis to low-dimensional chaotic states can be removed with the help of Takens-like theorems for spatially extended systems and delayed systems. With this the experimentally observed high-dimensional chaotic states in spatially extended systems and delayed systems allow for modelling and characterization in terms of invariant measures (Lyapunov exponents, dimensions, entropies). We present the successful application to high-dimensional laser data.

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CP15

Deterministic Structure in Data from a Free Running Neuronal Ensemble: A Comparison of Nonlinear Tests for Determinism

The search for convincing evidence of determinism in neuronal ensembles is difficult. We compare different strategies for detecting non-linear deterministic structure in interburst interval data taken from the rat hippocampal slice preparation. In particular, we used the following tests: 1)a periodic orbit detection algorithm (So.et al, Phys.Rev. E, 55 1997), 2)a continuity test (Kaplean, Physica D, 73 1994).

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CP15

Lyapunov Spectra from Sub-System Information in Spatio-Temporal Systems: a Time-Series Perspective

We characterise the chaotic behaviour in large spatio-temporal systems by estimating the Lyapunov spectrum from its rescaled counterpart obtained from sub-system information. We discuss a new, more accurate, rescaling technique and its properties. We consider the evolution in tangent space either given explicitly or reconstructed from time-series. We investigate the effects on replacing a large, and potentially infinite, system by a small truncated version with random boundary conditions.

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CP15

Spatiotemporal Chaos in Yttrium Iron Garnet Films

The spatiotemporal chaotic behavior of magnetostatic wave states in thin films of Yttrium Iron Garnet is experimentally studied. We use two experimental systems to study the spatial correlation of the chaotic state of the sample. In one experiment, we use two patterned slotline probes to simultaneously measure the magnetic state at two different positions on the sample; in the second experiment we use an optical system consisting of two laser beams to achieve improved resolution.

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CP15

Low-Dimensional Approximations to High-Dimensional Systems

Spatially extended, forced, dissipative systems can possess regimes in which they exhibit spatially coherent, low-dimensional behavior. Developing low-order models of such systems that capture the low-dimensional behavior can be challenging. Using numerical GCMs of single and double gyre oceanic circulations as base sytems, we compare results from several different Galerkin approaches to constructing low-order systems including projection onto Fourier, EOF, "snapshot", and displacement vector bases. The failure of the EOF approach is related to the EOF's distance from the inertial manifold.

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CP15

Locating Information Sources in Spatiotemporal Data

Measures of mutual similarity and coherence can be used to infer the relatedness of signals measured at different locations of a spatially extended evolving system. Clustering techniques can then be used to evaluate the spatiotemporal structure. Such an analysis can for example reveal locations with enhanced information poduction. The study is motivated by and successfully applied to the location of epileptic foci with grid electrode data.

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CP16

Period-Doubling Bifurcation Leading to Chaos in an Ecological Model

A qualitative analysis of a three-dimensional system of ordinary differential equations that model realistic ecological situations, taking into account some essential features of the dynamics of some systems in natural settings is given. Intensive numerical experiments show chaotic transition behavior when some parameters of the system vary according to biological principles. In addition, a perturbed version is studied with regards to certain fluctuations in the environmental conditions which naturally influence ecosystem dynamics.

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CP16

Nonlinear Stability of Age-dependent Population Dynamics

Multiple times scale analysis and bifurcation theory are applied to McKendrick's age-dependent population model, where the mortality function is independent of age. A weakly nonlinear analysis produces conditions under which nontrivial equilibrium age distributions lose stability and stable periodic solutions are born. These techniques, applied to the full partial differential equation model, provide information about the population density, unlike methods reducing the model to a system of ordinary differential equations.

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CP16

Complex Co-evolutionary Dynamics in Simple Ecological Foodwebs

Quantitative genetic recursion models are a set of integro-difference equations that describes the evolutionary dynamics of populations in which fitness depends on a continuous trait such as body size. These equations are solved using Fast Fourier Transforms and produce bifurcations and complex attractors of both body size and population size in foodwebs of 2 prey and 1 predator. I describe the nature of the attractors as affected by trait hereditability and environmental variability.

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CP16

Persistence and Extinction in Two Species Reaction-Diffusion Systems with Delays

Both uniform persistence and global extinction are established for two species predator-prey and competition reaction-diffusion systems with delays in terms of the principal eigenvalues of the scalar elliptic eigenvalue problems by appealing to the theories of abstract persistence, asymptotically autonomous semiflows and monotone dynamical systems.

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CP16

Urn Models, Replicator Equations and Genetic Drift

To understand the relative importance of natural selection and genetic drift in the evolutionary process, we study the asymptotic behavior of urn processes via the method of ODE. Of particular interest is the replicator process that represents pair-wise interactions between individuals in a finite population. We show how the limit sets of the replicator process and its averaged ODE (a replicator equation) are related and how genetic drift arises in the replicator process.

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CP16

Dynamical Behavior of a Discrete, Migration Model with Density-Dependent Selection

A system of nonlinear difference equations models the effects of selection and migration on a population characterized by two alleles at a single locus. It is shown that a destabilizing bifurcation caused by varying a selection parameter may be reversed by varying a migration parameter. The birth of a chaotic attractor in two dimensions is established as the result of a bifurcation from an invariant line where the dynamics are given by a one-humped chaotic map.

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CP17

Effect of Noise on Phase Synchronization of Coupled Chaotic Oscillators

We examine the effect of noise on phase synchronization of coupled chaotic oscillators. It is found that noise can induce phase splips between the oscillators in units of 2π. The average time for the oscillators to remain synchronized in phase depends on the noise strength, the scaling behavoir of which is investigated. Our results have implications to the observability of phase synchronization in laboratory experiments and this observability is quantified by scaling laws.

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CP17

From Mode-Locking to Chaos in Integrate-and-Fire Dynamical Systems

Integrate-and-fire mechanisms are often studied within the context of neural dynamics, although more recently their importance in nonlinear time series analysis has been realised. We show how to construct mode-locked solutions and Arnold tongue structures using recent techniques developed by the authors. The study of chaotic motion is made possible with an extension of the notion of the Liapunov exponent to discontinuous dynamical systems.

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CP17

Coupled Oscillators near Strong Resonances

It is well known that two coupled oscillators interact strongly when near a "strong resonance", that is when the ratio of frequencies is the ratio of two small integers. Investigations using normal forms give new insights into the dynamics of weakly coupled nonlinear oscillators, for the strong resonances 1:1, 2:1 and 1:0, near onset. A rich variety of complex dynamics and an application to neural oscillators will be outlined.

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CP17

Extreme Parametric Uncertainty and Instant Chaos and in Coupled Structural Dynamics

Nonlinear vibrations occur in linear structures coupled to nonlinear o scillators. Bifurcation to high-dimensional hyperchaos is observed in a driven coupled pendulum-flexible rod system. When the rod is in resonance with the pendulum, the system changes from a low dimensional periodic attractor to a high dimensional chaotic attractor abruptly. It is shown that high dimensional chaotic dynamics is hyster etic, and exhibits extreme sensitivity with res pect to small parameter changes

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CP17

Chaotic Oscillations in the Duffing Oscillator with High- and Low-Frequency External Forcing

In this paper we consider conditions of chaotic oscillations appearance in the Duffing oscillator, when this oscillator is excited with two frequencies, one of which is close to the oscillator natural frequency, and the other is much less than oscillator natural frequency. The comparison of obtained analytically criterion based on the Melnikov technique and numeric modeling results shows good agreement.

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CP17

Observability of Lag Synchronization of Coupled Chaotic Oscillators

Lag synchronization is a recently discoverd theoretical phenomenon where the dynamical variables of two coupled, nonidentical chaotic oscillators are synchronized with a time delay relative to each other. We investigate experimentally, numerically, and theoretically to what extent lag synchronization can be observed in physical systems where noise is inevitable. Our measurements and analyses suggest that lag synchronization is typically destroyed when noise level is comparable to the amount of average system mismatch. At small noise levels, lag synchronization occurs in an intermittent fashion.

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CP18

Hopf Bifurcation in Anisotropic Systems

Hopf bifurcation from group orbits of equilibria in 2D anisotropic PDEs is considered. With periodic boundary conditions imposed, the normal forms following from center bundle reduction are related to those of coupled cells with internal symmetries. For periodic solutions predicted by the equivariant Hopf bifurcation theorem, the dynamics along the group orbit is classified in terms of isotropy subgroups. Without spatial periodicity restrictions, globally coupled amplitude equations involving four wave variables give rise to Benjamin Feir type instabilities.

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CP18

Pattern Formation in Axial Compressors

Nonlinear dynamics of evolution equations governing the motion of fluid in jet engine axial compressors is discussed. The nature and stability of travelling wave solutions are investigated. Numerical results are compared with experimental data. Analogies with phase transition problems are pointed out.

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CP18

Dynamics of Spiral Waves in Weak Inhomogneity

The effects of weak inhomogeneity on spiral wave dynamics in the oscillatory regime is discussed within the framework of the two-dimensional complex Ginzburg-Landau equation description. The inhomogeneity gives spatial dependence to the frequency of spiral waves, thus providing a mechanism for one spiral domain to grow and dominate over the other spiral domains. The inhomogeneity also causes spiral vortices to slowly drift with velocities proportional to appropriate gradients of the inhomogeneity.

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CP18

Spiral Instabilities in Chemical and Biological Reaction-Diffusion Systems

Rotating spiral waves can be found in a large variety of chemical and biological systems. For certain parameter values, spirals break up, leading to spatio-temporal chaotic patterns. We investigate this transition using both a simple activator-inhibitor model and a model of propagation of intracellular calcium waves. We perform numerical simulations and stability analysis and find two distinct mechanisms of spiral breakup. They are related to convective and absolute instabilities of periodic planar wavetrains and are characterized by breakup near resp. far away from the center of the spiral.

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CP18

Scroll Wave Twist in the Presence of Rotational Anisotropy

Electrical waves in the heart propagate faster along the long axis of the muscle fibers. This axis rotates intramurally across the ventricular wall. We investigate numerically and analytically how scroll wave twist develops in a three-dimensional rectangular geometry as a consequence of this rotating anisotropy. We find the characteristic frequency of the twist is twice that of the unperturbed two-dimensional spiral. We present a phenomenological description of spatial behavior of twist in the linear regime.

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CP19

Targeting Applying ϵ-Bounded Orbit Correction Perturbations

A low-sized chaotic trajectory is used to compute *epsilon*-bounded orbit correction perturbations in order to rapidly target a trajectory from the vicinity of a starting point to a target. An algorithm that allows fast computation of a set of perturbations to be applied is presented, and its performance is tested in a higher-dimensional system, the kicked double rotor.

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CP19

Double Bracket Energy Sinks and Stabilization of Principal Axis Rotations

We introduce double bracket energy sinks: a large class of models useful for simulating energy dissipation in quasi-rigid spacecraft systems. We show that double bracket methods can also be applied to nonlinear stabilization of spacecraft minor axis rotations. We then analyze a multibody system in which the configuration manifold Q is not equal to the system symmetry group G. Applying non-

linear control in non-symmetry directions results in stabilization of intermediate axis rotations. The performance of multiple stable layout somersaults by human gymnasts provides the motivation for this work.

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CP19

Driving Trajectories in Complex Systems

We present a new paradigm, which combines targeting type of control problem for chaotic systems with the techniques used in system control theory, is proposed. This paradigm is used to rapidly change the evolution of a complex system among desired behaviors. We point out how this paradigm can also be used to nonlinear systems that do not present the characteristics of a complex system.

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CP19

Micro-Active Control of a Planar Jet

We present results of a combined experimental and numerical study of the transition to turbulence in a planar jet under the influence of micro-actuators. The jet first becomes unstable to two different kinds of periodic disturbance and we investigate the ability of the micro-actuators to control this low-dimensional behaviour. Thereafter, we consider controlling the mixing properties of the jet through qualitatively different types of disturbance.

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CP19

Combinatorial Optimization by Piecewise Continuous Dynamical Systems

A piecewise continuous dynamical system is introduced to solve combinatorial optimization problems like the two dimensional or the mathcal NP hard three dimensional assignment problem. There exists a bijective mapping from the set of feasible solutions to the set of asymptotically stable points of the dynamical system, i.e., the obtained solutions are always feasible. A criterion for global optimality of the obtained solution is given. Part of this is joint work with M.W. Hirsch.

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CP19

Quality Factor Control of Lasing Microcavities

We consider microcavities (1 to 10 μ in diameter) used as resonators in micro lasers. Ray circulation inside the cavity is modelled by a Hamiltonian map and follows a KAM transition to chaos. At high deformations light circulating inside such a cavity gets emitted by refraction. We present numerical results of controlling the residence time of light inside such a microcavity which is a measure of the quality of light emitted.

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CP20

Dynamical Systems Methods Applied to Polynomial Factorization Families: A Study of Chaotic Attractors

This talk will present families of discrete maps that utilize multi-dimensional Newton's method. The advantage is that an attractor is confined to a set of hyperplanes of the phase space. The explicitly defined maps on these hyperplanes can be utilized to predict the dynamics of the chaotic attractor. We have found analytic results on such important topics as attractor characterization, riddled basins, analytic calculation of Lyapunov exponents, topological conjugacies, and invariant measures on attractors.

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CP20

Pseudo-Riddling in Chaotic Systems

Previous investigation of the phenomenon of riddling has focused on the case where the dynamical invariant set in the symmetric invariant subspace of the system is an attracting chaotic set. A situation expected to occur commonly in physical systems is that the dynamics in the invariant subspace falls into a periodic window when a system parameter changes. We address whether riddling persists in such a case. In particular, we find that a mixed type of basin structure arises: locally riddled basins and basins of nonzero area. Scaling laws associated with this type of *pseudo-riddled* basin are derived and are supported by numerical experiments.

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CP20

The Topological Pressure for a Kind of Kicked Integrable Systems

In the present work, the statistical propierties displayed by an integrable system subjected by a chaotic force is studied. This perturbation is an infinite sequence of impulses applied in regular times, with a strength that is taken from a chaotic map. For this model, the topological pressure is exactly computed in the extended phase space, namely system plus perturbation, and its non analycities are interpreted as dynamical phase transitions on the corresponding Argand plane.

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CP20

Chaotic Sets Explosions: A Conjecture

We present a conjecture which puts different global bifurcations, such as crises (sudden changes in chaotic attractors), metamorphoses (sudden changes in basin boundaries), and explosions of chaotic saddles, into the same general setting. We identify a particular configuration of the stable and unstable manifolds (which we call an outer tangency) leading to the birth of new recurrent sets at a finite distance from any previous recurrent set. Numerical examples are presented to illustrate our conjecture.

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CP20

Life Expectancy Estimations of Transient Chaos

There are several engineering applications where transient chaos occurs: airplane nose gears, digitally controlled machines, machine tools during cutting, etc. The life expectancy of this behavior is an important parameter for the design work. To avoid extensive simulation work and the corresponding statistical analysis, approximate 1D maps may help to give simple analytical estimation for the life expectancy of chaotic behavior. This method is presented and the conditions of the above approximation are discussed.

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CP20

Weak Attractors and Basin Riddling

We introduce the concept of a weak attractor, a somewhat weaker definition of attractor than that suggested by Milnor. We demonstrate that there exists a Milnor attractor associated with the weak attractor and examine some properties of systems with these attractor types. We prove that under certain conditions one may classify the basin type of a Milnor attractor according to its containment within a weak attractor.

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CP21

Nonlinear Evolution, Filtering, Regularization and Control of Short Wave Instabilities

We will derive some model equations that arise in the geophysical context and describe the propagation of long nonlinear dispersive waves. We will present numerical schemes to solve these equations and present numerical results that show evidence of local and nonlocal solitary waves in these equations. Theoretical results related to structural stability, existence of perturbed solitary wave and singularity formation will be presented.

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CP21

Soliton Metamorphosis

Over the past several years, it has been possible to study the time evolution of a wide class of solitons and other nonlinear structures. New methods have been developed. A number of analytic techniques have also been introduced to study the stability of these structures. Finally, extensive, three dimensional numerical simulations have been performed. These both confirm and augment the analytic results.

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CP21

The Secret Lives of Kinks

Coherent structures in spatially extended systems at finite temperature follow stochastic paths. We analyse the stochastic PDE corresponding to ϕ^4 field theory in one space dimension. Kinks and antikinks are born in pairs. A pair may remain faithful (diffuse close to and annihilate with its partner) or one member may meet a an unfaithful death.

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CP21

Travelling Waves in a Model for Water Waves

We consider the general fifth-order Korteweg-de Vries equation

$$v_t+\gamma v_{yyyyy}+\delta v_{yyy}-\mu\partial_y\{2vv_{yy}+v_y^2\}+2\kappa vv_y+3r^2v^2v_y=0, \quad (0.1)$$

as model for the unidirectional propagation of shallow water waves over a flat surface. For some values of the parameters γ, δ, μ, κ and r, the existence of solitary waves of (0.1) has been proved by variational methods. In this paper we have proved the existence of *single bump* solitary waves and *periodic* wave trains described by (0.1) for more general values of the parameters by means of a topological shooting method. We also study qualitative properties of bounded solutions of (0.1) and asymptotic behaviour of the single bump solitary waves of equation (0.1).

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CP21

Internal Modes and Their Radiation Damping in Vector Solitons of Coupled Nonlinear Schrödinger Equations

Internal modes of vector solitons and their radiation-induced damping in the coupled nonlinear Schrödinger equations are studied. Bifurcation of internal modes from the integrable systems is analyzed. The region of existence of internal modes in the parameter space of vector solitons is also determined. In addition, radiation-induced damping of internal modes is investigated. Both exponential and algebraic decays of invernal oscillations are revealed.

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CP21

Multiple Pulses in Dispersive Quadratic Media

We consider an optics model describing second-harmonic generation and parametric wave interaction in quadratic media. The system consists of two nonlinearly coupled Schrödinger equations, and of particular interest are solitary-wave solutions for which both components are localised in the transverse spatial directions or in time. Applying rigorous methods from homoclinic bifurcation theory, the generation of multibump waves is demonstrated. The stability properties of these multiple pulses are then clarified, also using analytical techniques.

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CP22

Numerical Continuation of Periodic Orbits in Symmetric Hamiltonian Systems

Periodic orbits in dissipative systems are generically isolated and can be continued once the phase condition has been taken into account. In Hamiltonian systems periodic orbits are dense and can not be straightforwardly continued. This problem can be overcome by perturbing the system with a dissipative term and treat the periodic orbit as a Hopf Bifurcation at a vanishing value of this extra parameter. If a continuous symmetry is present, we have an additional degeneracy. In this work we propose an integral and a local condition to solve this difficulty and we present results for subharmonic bifurcations in several integrable and non-integrable hamiltonian systems.

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CP22

Numerical Solutions of a Lienard-type Equation

The Lienard-type equation The ODE will be transformed into a first order system for which a second-order method

will be developed as a linear combination of first-order methods. The fixed points of the numerical solution ($B(t) \equiv 0$) will be the same as the critical points of the Lienard equation and will have the same stability properties.

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CP22

The Dynamics of Adaptive Timestepping ODE Solvers

Many algorithms used to numerically integrate ODEs adaptively change the timestep as the integration progresses while satisfying some local error constraint. We consider a large class of such algorithms, based upon explicit Runge-Kutta methods, and analyze them as (discontinuous) dynamical systems. In particular we present stability results for the numerical methods under various structural assumptions on the ODEs, such as dissipativity, contractivity and gradient structure.

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CP22

Nonlinear Stability Analysis of Area-Preserving Integrators

Mathematical theory for the dynamics of area-preserving maps is not in a form that is readily applicable. Beginning with a precise statement of the Moser Twist Theorem and using the theory of normal forms, we obtain a rigorous and fairly complete determination of necessary and sufficient conditions for stability at elliptic equilibria. These conditions are applied to reversible symplectic integrators with special attention to stepsize restrictions for schemes such as leapfrog, implicit midpoint, and Störmer–Cowell.

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CP22

Using Differential Equation Solvers to Compute the Stable Manifold

We present an algorithm to compute the (one-dimensional) stable manifold of a differentiable map without using the inverse of the map. We view the stable manifold as locally the solution curve of a differential equation. The vector field is approximated and integrated numerically. After taking an ODE step, a corrector step yields a point on the approximated stable manifold. This method can be used to follow the manifold through the points where $\det Df = 0$.

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CP22

On Computational Aspects of Computer–Assisted Proofs of Chaos in ODE's

We discuss rigorous numerical methods used in computer–assisted proofs of chaotic behavior for the Lorenz equations by Mischaikow & Mrozek (BAMS'95) and for the Rössler equations by Zgliczyński (Nonlinearity'97). The main numerical problem in such a proof is our inability to obtain reasonable rigorous estimates for Lipschitz constants for the induced flow. This results in 20–60 hours of computer time requiredto complete the proof. We present a new method , based on the Lohner algorithm, which gives a considerable calculation time reduction (100x).

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CP23

Mixing in Compressible Flows

Mixing properties of three-dimensional compressible flows are investigated. The integrability and chaotic advection of these flows is discussed in the spirit of similar theories for incompressible flows. Applications in internal combustion engines are presented. Exit time plots and residence time plots in these flows are discussed and explored in terms of large-scale coherent structures.

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CP23

Advection of Finite Size Neutral Particles and Control of Hamiltonian Chaos

Trajectories of finite size neutral particles suspended in 2D incompressible flows separate from fluid trajectories. Given a drag coefficient γ, this sparation is stronger in the hyperbolic regions of the base flow. Thus, particles avoid the strongly chaotic regions flows, sticking to fluid trajectories with γ-bound Lyapunoff exponents. Under weak drag, the particles typically settle on KAM fluid trajectories inspiring a numerical scheme to detect KAM surfaces in arbitrary two-degre-of-freedom-Hamiltonian systems.

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CP23

Passive Tracer Dispersion in Fluids

In this talk, I will present results on dispersion of double passive tracers, passive tracers with random stopping at various sites, and passive tracers with time-dependent diffusivity. In the last case, the tracer concentration is modeled by a nonlocal advection-diffusion equation.

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CP23

Transport in Action-Angle-Angle Maps

The dynamics of a class of three-dimensional volume-preserving maps - the so-called action-action-angle maps - is discussed. A mechanism for transport found by Piro an Feingold is investigated rigorously in the perturbative set-up. A persistence theorem for periodic orbits is proven using an analogue of subharmonic Melnikov theory. A non-persistence theorem for a class of two-dimensional invariant manifolds is proven. These two results are used to show that transport involves a creation of a pair of hyperbolic fixed points close to a manifold on which a resonance condition is satisfied. Using this mechanism, a fast transport is achieved through a large portion of the phase space. Applications to three-dimensional perturbations of shear flows are presented.

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CP23

Matrix Approaches to Mixing Rates

It is often interesting to know how quickly a given dynamical system mixes to its natural invariant measure. This rate is given by the second largest eigenvalue of an associated transfer operator. Recent results by Keller and others suggest that Ulam–type matrix approximations may yield good spectral information in this setting. This talk will discuss the application of a trace formula based scheme to Ulam approximate matrices to compute mixing rates for various systems.

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CP23

Frequency Dependence of Chaotic Transport in the Presence of Diffusion

We study the combined effects of chaotic advection and molecular diffusion on a region of pollutant in simple, time periodic recirculating flows. We find that the flux function and the width of the stochastic zone in the non-diffusive systems have a universal frequency dependence. Furthermore, these systems have a universal adiabatic transport mechanism. These universal forms imply, as we demonstrate numerically, that diffusive, low frequency (*high frequency*) stirring leads to efficient transport on shorter (*longer*) time scales.

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CP24

Elliptic Problems on Domains with Rapidly Oscillating Boundaries

We consider elliptic boundary value problems subject to Robin (third type) boundary conditions on domains with rapidly oscillating boundaries. We ask what the limiting problem is as the oscillations get faster and faster and the domain approaches a smooth domain. In some cases we get a Robin problem with a different coefficient on the boundary, in other cases the Dirichlet problem.

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CP24
Continuation of Solutions to 1D and 2D Nonlinear Elliptic PDEs by the Multiquadric Method

The Multiquadric Radial Basis Function (MQ) Method is a collocation method with global basis functions. It is known to have exponential convergence for interpolation problems. We discretize nonlinear elliptic PDEs by the MQ method. This results in modest size systems of nonlinear algebraic equations which can be efficiently continued by standard continuation software such as AUTO. Examples are given of 1D and 2D PDEs. For these examples, the accuracy of detected bifurcation and the number of unknowns compare favourably with known results from the literature

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CP24
On the Vibrations of a Plate-Beam Structure

We consider the transversal deflections which may be large, of a dynamically- coupled Von Karman system consisting of a plate which has a beam attached to its one edge. The deflections of the coupled system is described by the nonlinear Von Karman system together with the beam equation, which is, however, compounded by the interaction of the beam and the plate. The problem is considered in the form of a non-linear evolution problem in a product space. We show the existence of a unique local solution by following a fractional powers approach to first construct a "weak" solution in a larger space. Regularity properties for this solution yield a unique local strong solution for the original boundary-value problem. This approach entails the introduction of fractional powers of a pair of matrices.

Prof. Marié Grobbelaar
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CP24
Asymptotic Analysis of a Spike-Type Solution of an Elliptic Equation

The boundary function method is used for construction of a spike-type solution of an elliptic equation in which nonlinear term depends on spatial variables. Under certain conditions the method allows to define the position of a spike without using exponential asymptotics.

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CP24
On the Multiplicity of Solutions of Two Nonlocal Variational Problems

In this joint work with Juncheng Wei, I study two nonlocal variational problems. One models micro-phase separation of diblock copolymers and the other models solid-solid phase transformations that lead to fine structures. I consider a parameter range where the problems can be approximated by their asymptotic limits. All the local minimum solutions of the limiting problems are found. Because these local minima are isolated, and hence stable under perturbation, near them there exist local minimum solutions of the original problems.

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CP24
Global Attractors for a Degenerate Equation from Viscoelasticity

We study a parabolic-hyperbolic partial differential equation modelling the forced longitudinal motions of a light nonlinearly viscoelastic rod attached to a heavy particle. Applying phase-plane methods to this infinite-dimensional problem, we prove that the equations have a global attractor. This attractor is contained in an inertial manifold on which the dynamics is governed by the classical ordinary differential equation describing the motion of the particle when the rod is massless.

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CP25
Dynamical Aspects of System Identification

System identification means using the inputs and outputs of a system to determinine a model that can reproduce its behavior. Often this can be done by observing an auxilliary dynamical system that takes the measured output of the original system as input. This talk examines this problem for the class of coupled oscillator systems. Issues addressed include performance criteria of the identifier and the effect of structural properties such as symmetry in the original system.

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CP25
Error Statistics, Model Selection and Confidence

in Chaotic Time-Series Prediction

The traditional approach to time-series embedding prediction has been by pointwise (usually linear) regression of the k-nearest neighbors, assuming a good embedding, and additive noise. With a finite data set, there is an inherent conflict between balancing the noise fluctuations of a small k, and large k data needs of fitting many parameters of large d. We develop tools to 1) select the statistically significant model for fixed k, 2) select the best k and model to optimize the resultant prediction, in the sense of having the smallest confidence bands for a fixed level of confidence.

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CP25

Symbolic Sequence Approach to Biological Oscillator Dynamics

Symbolic dynamics partitions phase space so that information about the underlying orbital skeleton is captured by the partitions, even in systems where noise precludes a generating partition. Analysis of the resulting symbol sequence statistics can show local dynamics including bifurcation behavior, as well as recurrence within and coupling between time series. We use a novel approach to symbolic analysis to characterize dynamics in systems of coupled biological oscillators.

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CP25

Interspike Interval Embedding Theorem

We give the proof of the Interspike Interval Embedding Theorem conjectured by T. Sauer, which applies to the data consisting of series of event timings. The theorem states that we do not lose any topological information through embedding process under some assumptions. The proof assumes that the event timings are created through so-called the "integrate-and-fire" model. We also consider the extension to the cases where the magnitude of the events are available.

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CP25

Sunspot Cycle: A Driven Nonlinear Oscillator?

A property of nonlinear oscillators – mutual dependence between their instantaneous amplitude and frequency is tested in the sunspot data using the surrogate data technique. The instantaneous amplitudes and frequencies are obtained by means of the analytic signal approach. In several tests the amplitude-frequency correlation has been found significant on levels ranging from $p < 0.03$ to $p < 0.07$, which supports the hypothesis of a driven nonlinear oscillator as a mechanism underlying the sunspot cycle.

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CP25

An Application of Computational Topology to Dynamical Systems

We present computational techniques that detect bifurcations in the topology of invariant sets. A familiar example comes from 2-d area-preserving twist maps. Invariant circles trap chaotic orbits and imply some degree of stability that is destroyed when the nonlinearity is increased. Analogous structures in higher-dimensional maps are difficult to visualise so computational tools are necessary to give quantatative information about their topology. In particular, we characterise how the number of components and number of holes vary with a resolution parameter.

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CP26

Adaptive Mesh Refinement for Simulating Excitable Media

Using an adaptive mesh refinement (AMR) method for hyperbolic equations formulated on hierarchical Cartesian meshes [1], we have investigated the accuracy, efficiency, and utility of AMR for simulating two- and three-dimensional excitable media, whose dynamics consist of propagating fronts with fast rise times and large spatial gradients. We summarize results for the Barkley and Luo-Rudy I models and discuss how the efficiency of AMR is related to the geometric structure of the fronts. [1] M. J.

Berger and P. Colella, J. Comp. Phys. 82, 64 (1989).

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CP26

Geometric Analysis of Population Rhythms in Neuronal Network Models with Fast Inhibitory Synapses

Geometric dynamical systems techniques yield insight into population rhythms, such as synchrony and clustering, in models of coupled neurons. Such analysis elucidates general mechanisms by which firing patterns arise and demonstrates how cells' intrinsic and synaptic properties shape network behavior. We employ this approach for models, based on the Hodgkin-Huxley formalism, relevant to thalamic activity during sleep and paroxysmal discharges. A key finding is that models with different complexity levels support qualitatively different synchronization mechanisms.

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CP26

The Viscous Nonlinear Dynamics of Twist and Writhe

Exploiting the "natural" frame, we formulate the intrinsic dynamics of twisted elastic filaments in viscous flow, in which coupled nonlinear equations describe the interplay of curvature and twist. These equations are used to illustrate *geometric untwisting* of open filaments, whereby twisting strains relax through a transient writhing instability without axial rotation. Experimentally-observed writhing motions in *Bacillus subtilis* fibers [Mendelson et al., *Journal of Bacteriology* **177**, 7060 (1995)] may be examples of this process.

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CP26

Chaos and Self-Organization in the Three-Letter Code Heteropolymer Model

Analysis of the radius of gyration, potential and kinetic energies obtained by Langevin molecular dynamics simulation of the three-letter code heteropolymer model indicates that the motion of typical α-helix and β-sheet structures is chaotic. Comparison between simulations at different temperatures shows that the folding process can be described as the typical behaviour of a dissipative system going to an attractor. The implications and new insight on how to analyse protein folding are discussed.

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CP27

Bifurcation Analysis of Spontaneous Symmetry-Breaking in Circular Josephson Junction Arrays

We use equivariant bifurcation theory to investigate subharmonic instabilities of the synchronous periodic state of circular arrays of N identical Josephson junctions. This instability gives rise to period-doubled solution branches, which when stable lead to a step in the $I - V$ curve. We determine existence and stability of the period-doubled solution branches as functions of the system parameters. For $N = 4, 9$, we determine the qualitatively distinct $I - V$ curves over a range of
parameters, and present numerical evidence supporting our results.

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CP27

Dynamics of Continuous-Time Boolean Networks and Parkinsonian Tremor

Analysis of continuous-time, binary-response networks allows us to relate network structures to dynamical behaviours. The form of an underlying discrete (fractional-linear) mapping encodes information on existence, stability and exact periods of periodic orbits. In specific cases aperiodic behaviour can be proven and its properties investigated. Global transitions from aperiodic to periodic regimes often result from local weakening of connections and are suggested as the mechanism behind tremor in Parkinson's disease.

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CP27

Spatiotemporal Organization in Long Chains of Chaotic Oscillators with Impurities

We investigate the influence of impurities introduced into lattices of coupled identical damped driven chaotic pendula and chaotic maps. Contrary to our expectations, a single impurity can control the chaotic behavior of a long array of chaotic oscillators and induce spatiotemporal organization. A spatial pattern emerges that is robust to variations in coupling strength and the length of the impurity pendulum. In addition, this effect appears to be independent of the size of the chain. A possible mechanism responsible for this phenomenon will be discussed.

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CP27

Instabilities and Discrete Rotating Waves in Coupled Chaotic Oscillators

We present results on chaotic oscillators that are linearly coupled by using periodic and free-end boundary conditions. The systems are characterized through a linear stability analysis applied to the homogeneous chaotic state. This kind of analysis unveils the appearance of instabilities, that yield different discrete spatio-temporal structures, that in many cases can be analyzed from the pattern of the bifurcation associated to the instability. These structures include those obtained from the so-called fast bifurcations.

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CP27

Synchronization in Arrays of Oscillators with Different Natural Frequencies

Arrays of oscillators whose natural frequencies increase linearly along the array are interesting in terms of different applications. For example, they can model the vortex shedding in a flow past cone-shaped bodies, peristaltic phenomena in mammalian small intestine and generation of cardiac rhythm in sinoatrial node. We study how small additions to the linear trend of natural frequencies and external forcing modify synchronous dynamics of arrays consisting of quasiharmonic or relaxational oscillators, thus providing possible ways to control such systems.

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CP27

Time Delay in the Kuramoto Model of Coupled Oscillators

We generalize the Kuramoto model of coupled phase oscillators to allow time-delayed interactions. New phenomena include bistability between synchronized and incoherent states, and unsteady solutions with time-dependent order parameters. We derive exact formulas for the stability boundaries of the incoherent and synchronized states as a function of the delay. The experimental implications of the model are discussed for populations of chirping crickets and for physical systems such as coupled phase-locked loops or lasers.

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CP28

Localized Traveling Waves Under the Influence of Temporal Modulation: Growing Worms and Pulses

Motivated by the observation of localized waves in binary-mixture convection ('pulses') and in electroconvection in nematics ('worms'), we investigate within coupled

Ginzburg-Landau equations their response to a temporally periodic modulation. Over a wide range of parameters their localization is due to a coupling to an additional slow mode. The modulation directly affects the speed of the localized waves. Due to the coupling to the additional mode, the change in speed strongly impacts their size.

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CP28

Multi-Phase Patterns in Periodically Forced Oscillatory Systems

Periodic forcing of an oscillatory system produces frequency locking bands within which the system frequency is rationally related to the forcing frequency. In spatially extended systems patterns form consisting of fronts separating the different phase-locked states. I will describe an instability of these fronts that causes a transition from stationary two-phase patterns to traveling n-phase patterns. This instability leads to, for example, the collapse of a four-phase spiral wave into a stationary two-phase pattern as the forcing strength within the 4:1 resonance is increased.

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CP28

Oscillatory Patterns in a Model of Autocatalytic Surface Reaction

A reaction-diffusion-equation for a mobile adsorbed CO-species is coupled with a system of three ordinary differential equations for adsorbed oxygen, a nonreconstructed catalytically active platinum surface, and subsurface oxygen. The latter functions as a memory for the active surface, that shows hysteresis in its phase transition. Bifurcation analysis finds critical parameters where changes in the qualitative behavior serve as a method to verify the mathematical model. Simulations of oscillatory patterns are compared to experimental observations.

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CP28

D_4-Equivariant Maps and the Takens–Bogdanov Bifurcation

In many double-diffusive convection problems, a Takens–Bogdanov (TB) bifurcation, at which primary Hopf and pitchfork bifurcations coincide, plays a major role in organising local and global bifurcations at nearby parameter values. The analysis of the TB bifurcation in two-dimensional convection has largely been completed, but the corresponding three-dimensional problem presents additional difficulties, particularly near the global bifurcations. I consider one case with D_4 symmetry in which the dynamics near the global bifurcation can be described by a generalisation of the well-known Lorenz map.

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CP28

Parametrically Excited Surface Waves: Normal Form Symmetries and Pattern Selection

Motivated by experiments on exotic standing wave patterns in the two-frequency Faraday experiment, we investigate the role of normal form symmetries in the pattern selection process. We focus on the situation where the trivial state loses stability simultaneously to harmonic and subharmonic waves of different wavenumbers. We show that the case where the harmonic waves have a longer wavelength than the subharmonic waves is markedly different from the case where the harmonic waves have a shorter wavelength.

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CP28

Travelling Front Solutions arising in a Chemotaxis-Growth Model

We consider a bistable reaction–diffusion–advection system describing the growth of biological individuals which move by diffusion and chemotaxis. To concern with the stability of envelope of growth patterns, we first prove the transversal stability of flat travelling front solution inside long channels. Numerical simulations show transitions from stable flat travelling front to spreading turbulance as the chemotaxis effect is stronger. The destabilized patterns evolve

into complex ones with network–like structures.

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CP29

Feedback Linearization of Unstable Rolling Phenomenon

We present several models of nonholonomic mechanical systems which exhibit unstable rolling characteristics (called shimmy) and their associated dynamics. The difference between the models relates to the relative sophistication of modeling the contact between a tire and the surface upon which it rolls. Feedback linearization is a standard nonlinear controller wherein a global nonlinear change of coordinates is constructed in which the control system is rendered linear. Unfortunately, this design technique applies only to a limited set of problems; however, this feature appears to be generic for the shimmy problems we consider. We present the simple application of this technique to the example shimmy problems and the geometric reason for its apparent general applicability.

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CP29

Dynamic Model Reduction

The subject of model reduction addresses the need for low order approximations of large systems of differential equations. This need is especially important in control theory, where efficency is key. A dynamical-systems-based approach to model reduction will be presented. The ideas originate from the nonlinear Galerkin methods from fluid dynamics. These methods have a natural extension to a model reduction setting. A new method will be derived, with analytic and numerical results.

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CP29

Swimming Dynamics of a Shape-Changing Object

The swim of a 2D object propelled by constant change of contour is studied. The coupled rigid-body/fluid dynamics is formulated into a system of integro-differential equations. Even when propelled by periodic and unintelligent swimming contours, chaotic trajectories are predicted. Presrcibed trajectory can be pursued through varying the driving contours. The dynamics of a falling paper and Sky Surfing are discussed in connection to the present system based on the same equations.

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CP29

Control of Distributed Autonomous Robotic Systems with underlying Task Assignment

We propose an error resistant control mechanism for distributed autonomous robotic units to navigate in an environment with obstacles where the robotic units have to be assigned to manufacturing targets in a cost effective way. Our dynamical systems approach allows self-organized control of these robots. The system's equations are based on the selection behavior known in pattern formation of physical, chemical and biological systems, and a Behavioral Forces model for pedestrian crowds.

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CP29

Finite-Dimensional Control of a Nonlinear Distributed Parameter System

We address the problem of regulating a dissipative PDE that models a reaction-diffusion process. A nonlinear model reduction method was employed to approximate the long-term behavior of the PDE dynamics by a dynamical system of finite, small dimension. Closing the obtained system with a linear controller effectively stabilizes the PDE truncation(s) locally; this does not, however, exploit the fully nonlinear reduced model. On the other hand, nonlinear, feedback linearizing control results in large control spillover to the residual modes. We design an inverse optimal control law and demonstrate its robustness with respect to fast unmodeled dynamics. Simulation results demonstrate the performance advantages of the inverse optimal control law over the linear quadratic regulator in stabilizing models derived from our illustrative example.

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CP29

Control and Tracking in the Diamagnetic Kepler Problem

We have studied the system of a charged particle in the presence of two competing potentials, the Coulomb field and an external magnetic field. The resulting nonlinear system has a quantal analog (the Diamagnetic Kepler problem(DKP))and has been fundamental in classical and quantal studies of chaos and its characterisation. We have achieved *control* and *tracking* of a number of classical unstable periodic orbits in various regimes of scaled energy and magnetic strength. The DKP Hamiltonian displays a very rich and complex dynamics that has created a number of difficulties for the application of standard control algorithms. Our solutions to these problems will be discussed. Furthermore, our tracking procedure allows us to follow the unstable periodic orbits for increasing scaled energy (for fixed scaled magnetic field) as the system evolves from a (almost) regular, to a mixed and finally, to a fully chaotic regime.

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CP30

The Breakdown of Shadowing in a Typical Physical System

The sinusoidally forced, damped, double pendulum is presented as a simple paradigm system that is unshadowable due to the presence in the attractor of periodic orbits that have different numbers of unstable directions. An argument is provided for the existence of parameter values where shadowing fails. Numerical simulations show attractors containing fixed points with different numbers of unstable directions. Finite-time Lyapunov exponents whose signs fluctuate, the hallmark of unshadowable systems, are also observed.

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CP30

Transition To High-Dimensional Chaos

High-dimensional chaotic systems are systems with more than one positive Lyapunov exponent. We investigate how high-dimensional chaos can arise when a system parameter changes. A route is identified whereby a subsystem undergoes a cascade of period-doubling bifurcations to low-dimensional chaos, after which the complementary subsystem becomes chaotic, leading to an additional positive Lyapunov exponent for the whole system. A characteristic feature of this route is that the second largest Lyapunov exponent passes through zero smoothly. Four examples are presented: a discrete-time map, a continuous-time flow, the double rotor map, and a population model for species dispersal in evolutionary ecology.

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CP30

Metamorphosis of Chaotic Saddle

Chaotic saddles are nonattracting dynamical invariant sets that can lead to a variety of physical phenomena. We report our finding and analysis of a type of discontinuous global bifurcation (metamorphosis) of chaotic saddle that occurs in high-dimensional chaotic systems with an invariant manifold. A metamorphosis occurs when a chaotic saddle, lying in the manifold, loses stability with respect to perturbations transverse to the invariant manifold. The fractal dimension of the chaotic saddle increases *abruptly* through the bifurcation. We illustrate our finding by using a system of coupled maps.

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CP30
Box Dynamics

We study maps in $\Re^2$ by placing a grid on the region of interest and finding all the gridboxes containing the image of each gridbox. Our technique determines the image of the *entire* box up to machine accuracy. We use graph theory algorithms to locate possible periodic orbits. With successive refinements, as small as 10^{-15}, we can verify that trajectories exist. Unlike work of Dellnitz and of Mischaikow, our method can find optimal trajectories.

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CP30
High-Quality Numerical Shadowing for Differential Equations

We present an algorithm for finding an orbit of a given chaotic dynamical model that shadows a given time series. The algorithm is applied, using as the given model a scheme for integrating the Lorenz equations. We demonstrate agreement of the resulting orbit with the equations of the dynamical model to within machine double precision for time series as long as 10^5 samples, corresponding to 100 Lyapunov times.

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CP30
Spurious Lyapunov Exponents Computed Using the Eckmann-Ruelle Procedure

Numerically computing Lyapunov exponents of a dynamical system from a time series of measurements produces spurious exponents. We examine the Eckmann-Ruelle procedure and determine explicit formulas for the computed exponents (true and spurious) in the low noise limit. For example, if one generically embeds a one-dimensional system with exponent h into m-dimensional space, the computed exponents will be $h, 2h, \ldots, mh$. Formulas for higher-dimensional cases will also be discussed.

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CP31
Large Discrete Breather Dynamics in the Presence of a Phonon Bath

The dynamics of the discrete nonlinear Schrödinger lattice initialized in a non-extensive manner is studied. The non-extensivity causes the system to stay in a non-equilibrium state for a very long transitory period of time where standard Boltzmann statistics is inappropriate. Alternative statistics based on a non-standard entropy concepts (such as *Tsallis entropy*) should be applied. Our study of the nonlinear system locked in this *meta-thermodynamic* state focuses on the dynamics of discrete breathers.

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CP31
Solitonic Excitations on Lattice Systems

The behavior of continuum solitonic excitations is well-understood. However, many interesting applications of soliton-exhibiting model systems (DNA, Josephson junction arrays or material dislocations) are inherently discrete. We will outline the radical modifications that discreteness entails(radiation effects, shape modes bifurcating from the essential spectrum, pinning, to name a few) and will attempt to explain via analytical (Evans functions, collective variable theories) and computational means these complex and exciting new phenomena.

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CP31
Global Boundary Stabilization of the Korteweg-de Vries-Burgers Equation

The problem of global exponential stabilization by boundary feedback for the Korteweg-de Vries-Burgers equation on the domain $[0, 1]$ is considered. We derive a control law of the form $u(0) = u_x(1) = u_{xx}(1) - k[u(1)^3 + u(1)] = 0$, where k is a sufficiently large positive constant, and prove that it guarantees L^2-global exponential stability, H^1-global asymptotic stability, and H^1-semiglobal exponential stability. The closed-loop system is shown to be well posed.

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CP31
Approximate Group Theoretic Laws for Self-focusing and Solitons

The group theoretic laws for paraxial self-focusing in cylindrical geometry and solitons governed by the nonlinear wave-equation are presented. The paraxial quasi-optic equation gives in this case the nonlinear Schrodinger equation solutions close to the exact solution but in a reduced regime of application. The dynamics of the width-eikonal are studied in this context using the the restricted Lorentz group, equivalent to the ABCD laws of gaussian beam propagation.

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CP31

Radiation Loss of Dispersion-Managed Solitons in Optical Fibers

Dispersion-managed optical fibers have been used to transmit soliton-like pulses that breathe as they propagate. Here, based upon the nonlinear Schrödinger equation with a periodic dispersion coefficient, we identify an intrinsic resonance mechanism causing such dispersion-managed 'solitons' to radiate and thus lose energy continuously. In the short dispersion-map period limit, the radiation loss is exponentially small and is calculated by using techniques of asymptotics beyond all orders.

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CP31

Periodic Solutions of Nonlinear Schrodinger Equation in the Strong Dispersion Management Regime

The technique of dispersion management for pulse propagation in telecommunication lines has been a subject of intensive theoretical, experimental, and numerical investigations in the last few years. The existence of a pulse which nearly resumes its shape after many periods of dispersion management has been shown numerically and confirmed by approximate analytic techniques. We prove that there exists a solution close to a periodic solution of the linear system for a long time.

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CP32

Unconditionally Gradient Stable Time Marching the Cahn-Hilliard Equation

Numerical methods for time stepping the Cahn-Hilliard equation are given and discussed. The methods are unconditionally gradient stable, and are uniquely solvable for all time steps. The schemes require the solution of ill-conditioned linear equations, and numerical methods to accurately solve these equations are also discussed.

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CP32

The Effects of Collocation Methods on Local Bifurcations of Flows

The common local bifurcations of scalar flows are transformed here under a class of algorithms known as linearized one-point collocation methods. Through normal forms, it is shown that each such bifurcation gives rise to an exactly corresponding one in its discretization. The conditions for spurious period doubling are derived. A singular set induced by the methods has behavioral consequences, including loss of monotinicity of solutions, intermittency, and attractor basin distortion.

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CP32

Robust Newton-Picard Methods for BifurcationA-analysis of Periodic Solutions of Partial Differential Equations

In this presentation, we will present some recent robustness-increasing enhancements which we have made to our single- and multiple shooting based Newton-Picard methods. By monitoring the convergence behavior, we have dramatically reduced the failure rate of the iterative solver. We will demonstrate these improvements with some test results. A free implementation of the algorithms is available.

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CP32

Finite Difference Approximations of Delay Differential Control Systems

This paper deals with optimal control problems for dynamical systems governed by differential inclusions with time delays. We develop a finite difference method for efficient approximations of such problems by optimal control problems with discrete time. Under general assumptions we establish well-posedness of discrete approximations that ensures a strong convergence of optimal solutions. Finally we apply this method and appropriate tools of variational analysis to obtain new necessary optimality conditions for control problems under consideration.

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CP32

A Dynamical System Associated with Newtown's Method for Parametric Approximations of Convex Minimization Problems

We study the existence and asymptotic convergence when $t \to +\infty$ for the trajectories generated by

$$\nabla^2 f(u(t), \epsilon(t))\dot{u}(t) + \dot{\epsilon}(t)\frac{\partial^2 f}{\partial\epsilon\partial x}(u(t), \epsilon(t)) + \nabla f(u(t), \epsilon(t)) = 0$$

where $\{f(\cdot, \epsilon)\}_{\epsilon>0}$ is a parametric family of convex functions which approximates a given convex function f we want to minimize, and $\epsilon(t)$ is a parametrization such that

$\epsilon(t) \to 0$ when $t \to +\infty$. This method is obtained from the following variational characterization of Newton's method (P_t^ϵ)

$u(t) \in \operatorname{argmin}\{f(x,\epsilon(t)) - e^{-t}\langle \nabla f(u_0,\epsilon_0), x\rangle : x \in H\}$

where H is a real Hilbert space. We find conditions on the approximating family $f(\cdot,\epsilon)$ and the parametrization $\epsilon(t)$ to ensure the norm convergence of the solution trajectories $u(t)$ towards a particular minimizer of f. The asymptotic estimates obtained allow us to study the rate of convergence as well. The results are illustrated through some applications to barrier and penalty methods for linear programming, and to viscosity methods for an abstract non-coercive variational problem. Comparisons with the steepest descent method are also provided.
This work was partially supported by Fondecyt 1961131. The work of J. M. Pérez C. was supported by funds from Fundación Andes.

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CP32

Numerical Computation of Solitons and Waves Using Adaptive Moving Grids

We present a sophisticated numerical method for approximating solutions of higher-order PDE models. These types of PDE models, such as the KWdV-equation, or suspension-bridge models, posses solutions with high spatial gradients that also move in time, for example as a soliton or as a wave. It is well-known that traditional methods on uniform meshes may have severe problems with efficiently and accurately computing numerical approximations. For this purpose, a special numerical method has been developed: a so-called adaptive moving grid method. Successful application of the method is shown for PDEs from different application areas.

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CP33

Turbulent Transport by Waves

We consider the *transport of a passive scalar* (like pollutant concentration, temperature, or dye concentration) in a prescribed velocity field which is a superposition of waves. The spreading of an oil spill on the ocean surface can serve as an example. We find an equation for the averaged concentration of the passive scalar. Besides the usual diffusion term, with a second derivative, this equation contains the dispersive term, with a third derivative. The formulas for the coefficients of turbulent diffusion and turbulent dispersion are derived. Both of them have the fourth order with respect to wave amplitudes.

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CP33

Lagrangian Diffusion in Chaotic Fluid Flows

Bidimensional turbulence is simulated by considering passively convected scalar gradients in chaotic fluid flows for a given spatially smooth velocity field. For periodic impulsive perturbations in the velocity, fluid flows are described by the standard map with a random phase. Anomalous diffusion processes associated with this map and their dependence on the control parameters are investigated. There is a competition between the enhancement of the diffusion coefficient, caused by accelerator modes, and its decrease due to the random phase.

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CP33

Slow Diffusion and Effective Stability of Dust Particles Orbiting Asteroids

Inspired by several planned space mission aimed at asteroid exploration, we study the dynamics of dust particles orbiting asteroids. Particular emphasis is placed on the diffusive motion in a neighborhood of linearly neutral, periodic orbits corresponding to tightly bound orbits about the asteroid. Through a Hamiltonian normal-form computation, we derive Nekhoroshev-type estimates that yield regions of effective stability, i.e., where the grains would remain for times exceeding the age of the solar system.

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CP33

Power Spectrum of Passive Scalars in Two Dimensional Chaotic Flows

We theoretically study the power spectrum of passive scalars being transported in two dimensional chaotic flows. Using a wave-packet method introduced by Antonsen et al., we numerically investigate several model flows, and confirm that the power spectrum has the k^{-1}-scaling, which was predicted by Batchelor but questioned by Williams et al. recently. On the other hand, we observe that the power spectrum has smoother roll-off than what is predicted by Batchelor. We find that disagreement is due to strong intermittency of stretching in the model flows.

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CP34

Mean Curvature Laws for Spreading Solid Films

An asymptotic treatment of solid films freezing onto undercooled substrates is developed. Contact conditions select the speed at which films advance; for rapidly spreading films these conditions may be applied directly to the asymptotic equations describing the film even though the underlying approximation is invalid at the contact line. Selected velocities are determined analytically in a secondary limit where laws of motion by mean curvature are derived describing the evolution of arbitrarily shaped contact lines.

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CP34

Optimal Gap Conditions for Invariant Manifolds

We give gap conditions for the existance of invariant manifolds for systems of semilinear differential equations in Banach Space. These conditions involve the growth bounds for the semigroups corresponding to the linear part of the equations and the Lipschitz constants of the nonlinear parts. These results are optimal for finite systems of equations, and can be extended to infinte systems and linear skew-product flows.

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CP34

Slow Manifolds and Inertial Manifolds in the Maxwell-Bloch Equations

We present examples of slow manifolds arising from two singularly perturbed PDE from laser phyics. These manifolds contain the asymptotic dynamics of the system and lead to a good understanding of the global dynamics and the structure of the attractor. Mathematically, it is a demonstration of the methods of geometric singular perturbation theory in infinite dimensions. We shall indicate connections of our work to recent persistence theorems of Bates *et al* for semiflows.

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CP34

On the Stabilization of Bounded Solutions for Parabolic Systems with Analitic Nonlinearity and Liapunov Functional

We consider the boundary value problem for nonlinear parabolic systems with analitic nonlinearyty and Liapunov functional. A solution of this problem is stabilized if the set of all partial limits of infinity consists of a unique stationary solution. We prove that every uniformly bounded solution of the problem stabilizes. If a solution is defined and uniformly bounded for negative time, it is shown that the solution stabilizes in backward time. Therefore, the global attractor of this problem consists of a stationary solution and of connected orbits. Moreover, flow on global attractor is a gradient-like flow.

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CP34

Structural Analysis of Incompressible Flows

I shall present a joint work with T. Ma on structural analysis of 2D incompressible flows. Topics include 1). structural classification, structural and block stability, and structural bifurcation of both divergence-free vector fields and solutions of Euler or Navier-Stokes equations, and 2). applications to the structure analysis of a wind-driven, double gyre, quasi-geostrophic ocean model, which is based on a joint paper with J. Shen and T. Tachim Medjo.

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CP35

Prediction and Noise Filtering in Dynamical Systems: A Neural Network Approach

The modeling of chaotic time series with neural networks has mainly been concerned with the development of architectures and learning paradigms that minimize the prediction error. On the other hand, a characterization of chaos in the framework of information theory provides a powerful statistical description that captures the essence of chaos by taking into account not only the short term prediction but the full evolution of uncertainty in terms of the *information flow*. In this contribution, we combine both strategies in order to extract the deterministic part of noisy chaotic systems. The noise filtering is obtained as the result of a neural network model selection based on a surrogate statistical test. In fact, the test selects a neural network deterministic model distorted with an estimated model of the noise which together show the same transmission of information in the future as in the original data. The methodology will be highlighted by several examples to assess its usefulness in the dynamical analysis of complex

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CP35

Tracking Doppler-Shifted Chaotic Waveforms

The idea of using chaotic waveforms in radar applications introduces the problem of tracking Doppler information contained in the received signal. In this paper, a model is presented for generating Doppler-shifted chaotic waveforms and a tracker is described capable of on-line estimation of the frequency shift. The tracker employs a response system containing a parameter that is controlled to simultaneously achieve synchronization and convergence of the parameter to the Doppler shift.

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CP35

Nonlinear Dynamic Signal Processing of Chaotic Noise in a Real Channel

This paper considers the use of nonlinear dynamic forecasting as a signal processing tool to remove background noise from a real channel. The examples include controlled experiments where the background noise is computer generated chaos obscuring speech signals in the room, as well as an experiment where the background noise was generated by a vibrating warehouse air handler system. Signal-to-noise ratio improvements and channel effects on the chaos will be discussed.

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CP35

The AWARE (Advanced Warning Against Runaway Events) Project

A device based on state space reconstruction from temperature measurements have been developed to detect in advance, for countermeasures be taken, the initiation of a runaway -thermal excursion of the reaction mass- in batch reactors. The development of the early warning detection criteria, based on an invariant property of the system, as well as the simulated and experimental verification in a small scale pilot reactor using an acid catalyzed esterification reaction are presented.

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CP35

Modeling of Large Scale Complex Adaptive Systems

The paper describes modeling techniques used to simulate and forecast demand for products, purchasing of which, is determined by social behavior more than by price (e.g., music CDs, movie tickets). We describe the methodology of Complex Adaptive Systems (CAS) that analyses dynamics of systems composed of large numbers of interacting individuals. We illustrate discussed concepts with simulation framework IceCore? created by ESG of PricewaterhouseCoopers LLP to design, simulate, and analyze large-scale CAS. We give examples of real life applications and numerical results illustrating advantages of CAS simulation compared to standard modeling techniques.

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CP36

Laser Spectral Waves: from Pattern Formation to Spatiotemporal Chaos

Longitudinal modes of an inhomogeneously broadened laser can behave as a chain of locally coupled oscillators, which displays instabilities that are rarely observed in other media. The negative-slope dispersion relation governing wave propagation inside the spectrum induces cascades of parametric instabilities. Furthermore, the natural nonuniformities of the medium (the lasing line shape) lead to recurrent phase-slips (ramp-induced Eckhaus instabilities). We observe each of these mechanisms and their related spatiotemporal chaos in a fiber laser experiment.

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CP36

Weak Synchronization of Chaotic Coupled Map

Lattices

Phase synchronized states can emerge in the collective behavior of an ensemble of chaotic coupled map lattices, due to a mean field interaction. This kind of interaction is responsible for synchronized chaotic global activities of the lattices, while the local activity of each map remains unsynchronized. The resulting collective dynamics is called "weak synchronization". The transition to such a state is characterized in an ensemble of one-dimensional lattices of logistic maps, in terms of the distance in phase among the different lattices. Its robustness against a small difference in the map parameters is proved. This phenomenon can be associated with pattern formation.

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CP36

Synchronized Finger Tapping and $1/f^{\alpha}$ Type Long Memory Processes

Imagine tapping your finger on a computer keyboard in synchrony with a periodic sequence of auditory beeps. The variability of your behavior is quantified by the small error you make on each tap. In particular, using an array of analytical techniques including the rescaled range analysis and the spectral maximum likelihood estimator, we establish that the synchronization error time series exhibits $1/f^{\alpha}$ type of long memory where α is about 0.5. We discuss the possible origin and functions of this process and point out future research directions

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CP36

Understanding Phase Synchronization in Terms of Periodic Orbits

Phase synchronization of chaotic oscillators can occur through phase-locking properties of the unstable periodic orbits embedded in a chaotic attractor. For each such orbit the phase-locked region can be constructed; we observe full phase synchronization when these regions overlap. The transition to this state arises via attractor-repeller collision.

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CP36

Destruction of Resonances in Two-Mode Quasilinear Dynamical Systems

Destruction of quasiperiodic oscillations through the interaction of two resonantly coupled modes is studied. The cases with $m < 5$, where m is the mode eigenfrequencies ratio, undergo detailed investigation. Equilibrium points properties are analyzed, conditions of the saddle-type points are found, the separatrix loop solutions are obtained analytically. Conditions of the invariant manifolds intersection under external periodic perturbation are found using Melnikov's technique.

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CP37

Spinodal Decomposition for the Cahn-Hilliard-Cook Equation - Linear Theory

The talk addresses the spinodal decomposition for the linearized stochastic Cahn-Hilliard-Cook equation $u_t = -\epsilon^2\Delta^2 u - \Delta u + \xi$ in Ω with Neumann and no flux boundary conditions. Ω is a domain with sufficiently smooth boundary and ξ a stochastic white noise. Based on the work of Maier-Paape and Wanner for the Cahn-Hilliard equation, it is shown, that with high probability a solution starting at $u = 0$ leaves a neighborhood of 0 along a strongly unstable manifold, provided ϵ small enough, which gives solutions with a characteristic wavelength.

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CP37

Pattern Evolution in the Discrete Cahn-Hilliard Equation

Lattice differential equations of Cahn-Hilliard type have solutions that exhibit similar behavior to that of the solutions of the analogous partial differential equation (such as spinodal decomposition followed by slow coarsening), in addition to lattice-induced effects not present in the spatially-continuous model. We will discuss the evolution of solutions on finite lattices, with emphasis on those phenomena unique to lattices and on the way that the grain pattern of the solution evolves.

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CP37

Existence of Connecting Orbits in Cahn-Hilliard

Using techniques based on Conley's connection matrix we will discuss the existence and structure of connecting orbits in Cahn-Hilliard.

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CP37

Allen-Cahn/Cahn-Hilliard Systems with Degenerate Mobility

Allen-Cahn/Cahn-Hilliard systems arise naturally in the context of modelling phase transitions exhibiting simultaneous order-disorder and phase separation. The degeneracy of the mobility reflects a possible vanishing of the mobility in the "pure" phases. Such systems can contribute to the understanding of wetting, prewetting, and interfacial adsorption phenomena. Existence results are presented for the degenerate system.

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CP37

Spinodal Decomposition for the Cahn-Hilliard Equation

If a homogeneous high-temperature mixture of metallic components is rapidly quenched to a certain lower temperature, then a sudden phase separation sets in. The mixture quickly becomes inhomogeneous and forms a fine-grained structure. This effect is called spinodal decomposition. My talk will describe numerical and theoretical results, explaining the mechanism for spinodal decomposition for binary and ternary alloys.

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CP37

Pattern Formation and Spatial Entropy in Spatially Discrete Cahn-Hilliard Equations

We consider arrays of scalar differential equations organized on a spatial lattice in a form analogous to the Cahn-Hilliard partial differential equation. With the so-called double obstacle nonlinearity we consider the existence and stability of a class of equilibrium solutions called mosaic solutions that take only the values $+1, -1$, and 0. We provide criteria for weak Lyapunov and weak asymptotic stability. Rigorous results are then obtained for the spatial entropy of these stable mosaic solutions.

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CP38

Fronts and Pulses in Reaction-Diffusion Equations and Their Stability

We reduce certain reaction-diffusion equations with two time scales by a traveling wave Ansatz to obtain a system of singularly perturbed ODEs. Homoclinic or heteroclinic solutions of the ODE system represent traveling front or pulse solutions of the original equations. By geometrical methods we find homo- and heteroclinic orbits with multiple loops, corresponding to solutions with multiple fronts or pulses. In the original reaction diffusion equations we study stability of these patterns.

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CP38

The Coupled, Weakly-Nonlinear Evolution of Two Counter-Rotating Waves and The Associated Streaming Flow in Finite Geometries

A novel set of coupled amplitude-streaming flow (CASF) equations will be presented, that includes the coupled evolution of two counter-rotating waves and the associated streaming flow, in finite geometries (such as the capillary bridge geometry), under nonaxisymmetric forcing. The CASF equations will be discussed, and several numerically obtained results will be presented and explained on the light of linear stability properties of the simplest standing wave solutions.

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CP38

Linear Conversion of Parallel Waves

Consider two waves propagating in one direction and separately trapped in another direction, with small overlap of the two wave-fields. The energy of one wave is gradually transferred to the other, if they are locally resonant; i.e., they have (locally) equal frequency and wavenumber. As an application of our general theory, we consider tropical-Atlantic low-frequency (period $\sim$ 3 weeks), long-wave (wave-length $\sim$ 1000 km) internal waves involving vertical displacement of the thermocline.

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CP38

Dynamics of Counterpropagating Waves in Parametrically Forced Systems

Parametrically forced counterpropagating waves in weakly dissipative fluid systems of moderately large aspect ratio are described by a pair of nonlocal equations for the (complex) amplitudes of the waves. These equations are solved in both annular and bounded geometries with sidewalls. Aside from spatially uniform standing waves these equations also describe spatially nonuniform states with simple and complex time-dependence. The nature of these states and transitions among them are investigated as a function of the forcing.

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CP38

Dynamics of Solitary Pulses in Isotropic and Anisotropic Reaction Diffusion Systems

Concentration pulses in a model of CO oxidation on Pt(110) undergo different types of instabilities (from modulated travelling waves, to"backfiring" and spatiotemporal chaos) as problem parameters vary. These instabilities are studied in parallel in the PDE and through the travelling waves ODEs. Pulse dynamics in thin annular anisotropic domains are reduced to that in 1-D media with position dependent properties. The effects of anisotropy are probed using simulation and numerical bifurcation analysis.

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CP38

Dynamics, Bifurcations, and Stability of Fronts in the Optical Parametric Oscillator

We consider the dynamics, stability and bifurcation of front structures of the optical parametric oscillator. Front solutions bifurcate super-critically from the trivial solution to a neutrally stable, translationally invariant front. Perturbations such as white-noise, group-velocity walk-off, or non-uniform pumping simply shift the center position of the front solution. For 2D fronts, the front curvature is governed by the heat equation so that only stripes are supported for long times.

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CP39

Non-Local Reaction-Diffusion Equations for Microwave Heating Applications

Motivated by recent microwave heating experiments on ceramic fibers in single-mode cavities, we present a new geometric approach to establishing the existence and stability of n-pulse solutions of a non-local reaction diffusion equation. Existence of solutions is determined by showing that the pulses lie in the transverse intersection of relevant invariant manifolds. The transverse intersection encodes a consistency condition that all non-local equations must satisfy. Stability is determined by locating the spectrum of a non-local Sturm-Liouville operator. We show that the n-pulse is metastable if $n = 1$ and unstable otherwise.

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CP39

Nonlinear Physical Forcing of Biological Populations

The relative contributions of physical and biological processes in forcing natural populations remains a central issue in population dynamics. Here, I demonstrate that the episodic nature of the re-supply of certain open marine populations can arise through nonlinear biological responses to random physical forcing. This suggests that biological processes can act as a non-linear amplifier of environmental fluctuations. Nonlinear techniques may therefore succeed where linear methods have failed in detecting physical forcing in natural systems.

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CP39

Spatially Complex Localisation in Twisted Constrained Elastic Rods

We study localized deformations of twisted rods constrained to either a planar or cylindrical surface. Such rods have applications in, e.g., drill strings and pipelines. Localised solutions are described by homoclinic orbits to a periodic solution representing a spatially-homogeneous rod. For isotropic rods we recover results for the elastica and the helix, with twist simply being superimposed. For anisotropic rods we find spatial chaos with an infinity of localised solutions, a sample of which are computed using a shooting method. In the cylindrical case a central role is played by a heteroclinic tangency.

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CP39

Weather Prediction and Residual Delay Maps: Isolating Regions of Atmospheric Nonlinearity to Compare Different Atmospheric Models

Residual Delay Maps have been used in the past to show how to extract additional dynamical information from univariate, noisy time series. One application has been to improve local weather prediction. We extend these results to identify regions of the atmosphere where nonlinearity is an essential component of the natural dynamics. With these results, we provide a qualitative test for comparing different atmospheric models and in the process of doing so we uncover some striking new observations about the global atmospheric system.

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CP39

Detecting Invariant Manifolds in Time Series: Biological Data

Special dynamical behaviors like synchronization, collective behavior, and pattern formation are often the result of a system evolving on an invariant, lower-dimensional manifold in its state space. Approaches for searching for dynamical manifolds using experimental time series are presented. In particular, one derived from a statistic for continuity shows evidence for an invariant manifold in coupled lobster neurons despite the lack of simple synchronization or any cross correlation between the neurons.

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CP40

Dynamics of a Chaotic Magnetic Limiter in Tokamaks

A sympletic mapping of magnetic field lines in a Tokamak perturbed by a chaotic limiter is presented. Bifurcation sequences are controled by the resonant perturbations, which create structures on the parameter plane interpreted as a process of growing and destruction of secondary islands.

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CP40

Power Limited Optimal Rendezvous Between Spacecraft

The minimum-fuel rendezvous problem between several power-limited low-thrust spacecraft in the neighborhood of circular or elliptic orbits is investigated. Cooperative maneuvers are simulated using the maximum principle of Pontryagin. Planar motions in the Clohessy-Wiltshire and the inverse square law gravitational fields are treated. Numerical solutions using shooting methods as well as finite-difference methods were used to solve the resulting two-point boundary value problems.

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CP40

Evolving Perturbed Hamiltonian Systems with Lie Transformations

Time evolution of a Hamiltonian system can be considered a canonical transformation and thus represented by Lie transformations. Methods for perturbations included in the phase space were developed by Dragt and coworkers; here I generalize to all perturbed Hamiltonian systems. Perturbation parameters need not be associated with the phase space variables: both "internal" and "external" perturbations are treated equivalently. Applications to areas as diverse as celestial mechanics, accelerator physics and light optics are possible.

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CP40
Experimental Observation of Chaos in a Plasma Discharge Tube

Contemporary Geissler tube configuration and drive circuits will be introduced. Experimental configurations for observing light intensity as a function of time at multiple configurations, hybrid imaging, and digital high-speed video techniques will be presented. Data-visualization techniques provide a powerful mechanism for combining the acquired data and imagery to build a coherent understanding of the system's behavior.

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CP40
Solutions of the Vlasov-Fokker-Planck Equation for Electrons in a Storage Ring

The V-F-P equation describes harmonic synchrotron oscillations perturbed by the self-field of the charge distribution and noisy synchrotron radiation. It is a nonlinear functional-differential equation for the distribution function $\psi(q,p,t) : \mathbf{R}^2 \times \mathbf{R}\ rightarrow \mathbf{R}^+$. The equilibrium solution is given by a nonlinear integral equation that is analyzed by a fixed-point method and solved numerically. The time-dependent problem is treated as a system of ODE's, after discretization in (q,p).

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CP40
An Optimal Control Problem for Satellite Dynamics via Wavelets

We consider applications of methods from wavelet analysis to optimal control problem for spacecraft dynamics. We present constructions which give explicit in time representations for the controlling and controllable variables in different types of well localized bases for the general classes of functional spaces with sparse representation for the corresponding operators. We also consider the problem of practical realization of the computed solutions and applications to problems of chaotic dynamics.

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CP41
Modelling Edge Detection Using A Network Of Pulse-Coupled Neurons

A simulation of an edge detector using a biologically realistic pulse-coupled neural network is presented. A static 2D image is mapped onto a grid of units, which oscillate in synchrony in the absence of image stimulus. Edges are phase-coded and detected as units that are out of phase with their neighbours. The problem is formulated and analysed from a dynamical systems perspective.

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CP41
Complex Behavior in Quasiperiodically Forced Biological Oscillators

We study biological oscillators subject to the influence of two external periodic signals with incommensurate frequencies. These oscillators can exhibit a complex behavior without being chaotic. The corresponding attractors can be characterized as structures in-between regularity and chaos. They are nonchaotic in the dynamical sense but they have a strange geometrical structure. We discuss their appearance due to collision bifurcations between stable and unstable invariant sets as well as the consequences of their existence for phase-lockings.

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CP41
Synchronization of Noisy Systems by Stochastic Signals

The nonlinear response of noisy bistable and neuron systems to stochastic external signal, represented by Markovian dichotomic noise, is studied in terms of synchronization. We propose a general kinetic model, which allowed us to conduct a full analytical study of nonlinear response, including calculation of cross-correlation measures, the mean switching frequency and synchronization regions. We have shown, that dichotomic noise can synchronize instantaneously the switching process of the system.

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CP41

Detecting Weak Interaction from Bivariate Data

Weak forcing of a noisy chaotic oscillator by another one, or interaction of such oscillators, may result in their phase synchronization. Here we use this idea to approach the inverse problem: to reveal a weak interaction from bivariate time series. As examples we study interrelation between human cardiovascular and respiratory systems and between brain areas involved in generation of pathological movements (Parkinsonian tremor). The information we extract cannot be obtained by traditional linear techniques.

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CP41

Embedding and Reconstruction of Forced systems

The analysis and interpretation of time series obtained from dynamical systems is usually based on delay reconstruction methods. These rely on Takens Embedding Theorem for their justification. When systems are forced, whether deterministically or stochastically, this theorem is not applicable. We describe how to extend it to forced systems and discuss the implications for the structure of the resulting time series. Finally, we speculate on the generalization of these ideas to spatio-temporal systems.

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CP42

Instabilities of Hexagonal Pattern in the Presence of Rotation

Stimulated by the complex dynamics of rolls in rotating convection we study the stability of hexagonal patterns with broken chiral symmetry. Within a model of three coupled Ginzburg-Landau equations we consider the stability of both stationary and oscillating hexagons. In the latter case we derive the equation for the amplitude of the oscillation, coupled to the two translation modes of the underlying hexagonal pattern. The stability results are compared with numerical simulations.

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CP42

An Analysis of Cellular Flame Patterns

A method to analyze cellular flame patterns on a circular domain is presented. The first step is a modal decomposition through Karhunen-Loève (KL) decomposition. Pairs of KL-modes are then combined to form effective Fourier-Bessel modes, which allow the deduction of complex time-dependent amplitudes from experimental states. Their symmetries are used to deduce the normal form equations. Applications to the analysis to rotating rings of cells and "hopping" states will be presented.

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CP42

Cross-Newell Equations for Triangles and Hexagons

This paper derives the Cross-Newell equations for triangular and hexagonal patterns in a large aspect ratio system. In general the resulting phase equations cannot be written in flux-divergence form, in contrast to the case of roll patterns. The consequences for defect formation in extended hexagonal patterns are explored. The phase stability boundaries for hexagons are also recovered from the phase equations in this new formalism.

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CP42

Super-Patterns and Parameter Collapse in Reaction-Diffusion Systems

A bifurcation analysis near a Turing instability determines the relative stability of simple patterns (stripes, hexagons) and more exotic, spatially periodic "super" patterns in reaction-diffusion systems. Explicit calculation shows that all system parameters collapse into relatively few effective parameters within the bifurcation equation coefficients. Moreover, in two-component systems several effective parameters disappear completely from the standard degenerate hexagonal lattice bifurcation problem. Nevertheless, even with these restrictions super-patterns may indeed form stably.

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CP42

Modal Decomposition of Hopping States in Cellular Flames

We use Karhunen-Loève (KL) decomposition of video images from an experiment to analyze a spatio-temporal dynamic state, unique to cellular flames, referred to as "hopping states". KL decomposition separates the spatial and temporal characteristics of the hopping motion. The underlying symmetries of the experiment allow us to deduce a set of normal form equations to describe the bifurcation and evolution of these states.

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CP42

Multibump Patterns Near a Co-Dimension 2 Point

The behaviour of marginally unstable small solutions in a reaction-diffusion model problem is studied near a co-dimension 2 point. At this co-dimension 2 point the 'classical' Ginzburg-Landau (GL) equation approximation breaks down. It is shown that the evolution of small solutions is described by different types of extended Fisher-Kolmogorov equations. The asymptotic analysis is compared to numerical simulations: asymptotically stable multibump patterns are observed. These multibump patterns are found theoretically by applying normal form theory.

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CP43

Topological Bifurcations in the Vortex Breakdown

A vortex breakdown is the creation of secondary flow structures in rotating flows. We develop a normal form for streamline patterns from which bifurcations up to codimension 3 are easily constructed. The bifurcation diagrams are used in conjunction with numerical simulations to systematically determine the bifurcation diagram for the much studied flow in a closed container with rotating end-covers. Good agreement with experimental results is obtained, and some hitherto unresolved details are determined.

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CP43

Tracer Dynamics in a Flow of Driven Vortices

We report on the Lagrangian dynamics of an array of driven vortices for which a low-dimensional streamfunction model was derived from numerical computations of the two-dimensional Navier-Stokes equations. We give evidence that the dynamics of passive tracers is essentially controlled by the existence of a chaotic saddle for which its stable and unstable manifolds are approximated. By introducing symbolic dynamics, we characterize the spatiotemporal properties of the tracers by the Shannon entropy.

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CP43

Five Point Vortices which Exhibit Relaxation Oscillation

The motion of assembly of point vortices in the two-dimensional Euler flow is a classical problem, which is described by a ordinary differential equation. For some five point vortices problem, a corotating motion with relaxation oscillation occurs for some vortex strengths. The purpose of this talk is to analyze such a motion. To this end we prove the existence of heteroclinic orbits. It is also shown periodic and chaotic motions of the vortices.

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CP43

Chaotic Dynamics in Vortex Cores

Vortex-blob computations were performed for the roll-up of a planar and an axisymmetric vortex sheet into a vortex pair and a vortex ring, respectively. The computations reveal the onset of chaotic dynamics due to resonance phenomena in the vortex core and a heteroclinic tangle at the rear of the vortex ring. The chaos arises from self-sustained

oscillations in the core vorticity. We investigate the extent to which the observed dynamics are present in real (viscous) flows.

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CP43

Instabilities of Vortex Filaments in Oscillatory Media

We study vortex filaments subjected to a uniform density of phase twist in three-dimensional oscillatory media. We show that, in a large region of parameter space, the first instability is a supercritical Hopf bifurcation to stable propagating helical vortices and that the secondary instability, leads to quasiperiodic supercoiled filaments. Further regimes are also discussed. We comment on the similarity between the changes undergone by these dynamical objects and those of twisted elastic rods.

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CP44

Numerical Simulations of Complex Flows of LCPs Based on the Doi Theory

In this talk, we present numerical simulations of inhomogeneous flows of liquid-crystalline polymers. The Doi theory, with a closure approximation, is used for the calculations. Based on the results, we explore the mechanisms for the generation of disclinations and the effects of the coupling between flow and the polymer configuration. Channel flows with expansions experience a peculiar instability which bears remarkable resemblance to patterns observed in experiments.

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CP44

A Continuum-Mechanical Theory for Nematic Elastomers

We develop a continuum theory for the mechanical behavior of rubber-like solids that have been formed by the cross-linking of polymeric fluids which include nematic molecules as elements of their main-chains and/or as pendant side-groups.

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CP44

Stress Selection and Phase Separation in the Doi Model for Solutions of Liquid Crystalline Polymers

Many complex fluids exhibit "phase transitions" in shear flow. I will discuss a modified version of the Doi model for rigid-rod suspensions. By incorporating spatial gradients we can unambiguously calculate the "phase boundaries" in shear flow, for which coexistence corresponds to a heteroclinic orbit in an equivalent dynamical system. I will explore some qualitative aspects of phase separation in shear flow, and discuss simpler model calculations which investigate the effects of curved boundary conditions.

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CP44

Capillary Instability in Free Surface Jets of Liquid Crystal Polymers

We investigate the capillary intability for free surface jet flows of liquid crystal polymers using a Doi type theory for homogeneous liquid crystals. We also consider the influence of surface elastic effects arising from the possible deviation between the orientation in the bulk and the preferred surface orientation. Restricting to slender jets, we address the issue of transient stability for two special jets under the influence of gravity, in which the orientation induced axial stress plays the dominant role in determining stability.

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CP44

Nonisothermal Spinning of Lyotropic and Thermotropic Liquid Crystalline Polymers

Previous slender one-dimensional models for axisymmetric filaments of liquid crystalline polymers (LCPs) are extended to include temperature-dependent material behavior and an energy equation. We present families of numerical steady boundary-value solutions for thermal spinning flows; effects such as temperature-dependent viscosity and LCP relaxation are modeled and exhibited. The predictions focus on thermal influence on spun fiber performance properties and process stability. This is joint work with M.G. Forest and Q. Wang.

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MS01

Regenerative Effect and Chatter: An Analytical Study

A phenomenon commonly encountered during machining operations is chatter. It manifests itself as a vibration between workpiece and cutting tool, leading to poor surface finish and dimensional accuracy of the workpiece and reducing the usefl life of the cutter. The onset of chatter acts as an upper bound on the cutting speed, limiting material removal rates and productivity. The mathematical models representing chatter dynamics have been cast as differential equations with delay, admitting periodic, quasi-periodic and aperiodic tool vibrations. By adapting existing mathematical techniques, we shall obtain finite-dimensional equations in order to systematically study the nonlinear behavior of machine tool chatter.

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MS01

Nonexpansive Periodic Operators in $\ell_1(\mathbf{Z})$ and Super-high-frequency Solutions of a Discontinuous Differential-Delay Equation

We study the discontinuous differential delay equation

$$x'(t) = -sgn(x(t-1)) + f(x(t)) \tag{0.2}$$

where

$$sgn(x) = 1 \quad \text{for } x < 0,$$
$$sgn(0) = 0,$$

and

$$sgn(x) = -1 \quad \text{for } x < 0.$$

We assume that f is locally Lipschitzian and that $|f(x)| < 1$ for all x. Suppose that $x|[-1,0] = \varphi$ and $x(t)$ satisfies (0.1) for $t \geq 0$. If φ is not identically zero or if $f(0) \neq 0$, we prove that there exist $t_\varphi \geq 0$ and an integer n_φ such that x has at most n_φ zeros on any interval $(t-1, t)$ for $t \geq t_\varphi$. A key role is played by the study of certain "periodic" nonlinear operators $\Phi : \ell_1(\mathbf{Z}) \to \ell_1(\mathbf{Z})$ which do not increase distance. The operators Φ have independent interest.

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MS01

Dynamics of Time-Delayed Ring Laser Systems

The light produced by erbium doped fiber ring lasers, of direct relevance to optical communications, is often chaotic in its dynamics. A rich variety of temporal patterns of the light intensity and very interesting fluctuations of the light polarization are observed. These very long cavity fiber lasers may be described by delay equations for the electric field and a coupled differential equation for the population inversion, based on the Ikeda model. We will compare experimental observations to predictions from the model and examine the influence of noise sources on the dynamics.

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MS01

Delay and Traveling Waves in Reaction-Diffusion Equations

We consider traveling wave solutions in delayed reaction diffusion equations. By using monotone dynamical systems approach, we establish some existence results. We then apply these results to some particular equations to obtain delay-induced traveling waves.

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MS02

Experimental Evaluation of Several Proposed Criteria for Synchronization

We couple two electronic oscillators to evaluate several recently proposed criteria for synchronization. The oscillators reside on a stable periodic orbit but small perturbations due to noise can give rise to large transient excursions from the orbit. We compare the range of coupling strengths over which a high degree of synchronization is observed with the theoretical predictions. We find that most of the criteria fail because they are not sensitive to transient growth of perturbations.

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MS02

Using Two-Attractor Chaotic Systems for Communication

Self-synchronizing chaotic systems, used for communications, are very sensitive to noise. We show a technique for communicating using a chaotic system with two attractors, with the attractors as communications symbols. We are able to improve the noise robustness of chaotic communication compared to parameter modulation. Our chaotic receiver displays some interesting physics- it recognizes which attractor the transmitter is in, but does not actually syn-

chronize to the transmitter, not even in the general sense.

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MS02

Invariant Manifolds and Chaotic Synchronization

The theory of k-hyperbolic invariant manifolds offers a natural framework for the study of chaotic synchronization. Many of the different types of synchronization that have been studied can be readily described in this framework. Furthermore this view provides both natural conditions for the persistence of smooth synchronization and a new set of Lyapunov type numbers to determine the onset of synchronization and leads to a duality between unidirectional and bidirectional synchronized systems.

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MS02

Unstable Dimension Variability and Modeling of Coupled Chaotic Oscillators

Systems of coupled chaotic oscillators arise in many situations of physical and biological interest. We present an analysis and numerical evidence for a particular type of nonhyperbolic behavior in these systems: *unstable dimension variability*. We show that unstable periodic orbits embedded in the chaotic attractor in the synchronization manifold of the system typically have distinct numbers of unstable directions. The consequence of this type of nonhyperbolicity is severe: the system cannot be modeled deterministically in the sense that no model trajectory can be realized by the natural system that the model is supposed to describe. We argue that unstable dimension variability arises for arbitrarily small values of the coupling constant.

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MS03

Recurrence Plots Revisited

We show that recurrence plots give detailed characterizations of non-stationary time series generated by dynamical systems driven by slowly varying external forces. For deterministic systems we can infer information about the driving force from the recurrence plot of the time series. Similar results hold for stochastic systems, when the recurrence plot is suitably averaged and transformed. These results are used for time series prediction and for detection of small changes in the driving forces.

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MS03

Coping With Non-Stationarity By Over-Embedding

Drifting parameters as the source of non-stationarity of otherwise almost deterministic systems can be identified by a reconstruction of an extended phase space by the method of delays. We discuss under which conditions the deterministic dynamics and the non-observed drifting parameters can be reconstructed implicitly. This concept is applied to numerically generated data and to human speech.

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MS03

Clusters As Basis for Study of Nonstationary Time Series

Many nonstationary signals may be viewed as the output of a dynamical system that moves around in parameter space in the course of the measurement period. We propose to use clusters of episodes with similar dynamics as an empirical basis in parameter space. We discuss measures of dynamical similarity and show some simple applications.

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MS03

Testing Stationarity in Time Series

We propose a procedure for testing stationarity of time series by combining a test for time independence of the 1D probability density with one of the spectral density. The potentials and limits of this test procedure are established by its application to different types of numerically generated time series ranging from simple linear stochastic processes to high-dimensional transient chaos as well as to observational data from geophysics and physiology.

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MS04

Equilibrium Statistics and Dynamics of Point Vor-

tices on a Rotating Sphere

Large scale coherent structures of barotropic flows on a sphere are characterized in terms of the most probable states of a statistical mean field theory (MFT). This MFT is obtained by formulating the Onsager-Joyce-Montgomery (OJM) theory in spherical geometry, starting from the spherical point vortex model (SPVM). The hamiltonian structure and symmetries give rise to the constraints in a maximum entropy derivation of the mean field equations. A second derivation uses the Bogoliubov-Feynman inequality for the free energy.

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MS04

Discrete Euler-Poincaré and Lie-Poisson Equations

Discrete analogues of Euler-Poincaré and Lie-Poisson reduction theory are developed for systems on finite dimensional Lie groups G with Lagrangians $\mathcal{L} : TG \rightarrow \mathbb{R}$ that are G-invariant. These discrete equations provide "reduced" numerical algorithms - discrete Euler-Poincaré (DEP) equations - which preserve the symplectic structure. Reconstruction recovers the discrete Euler-Lagrange equations which are symplectic-momentum algorithms. The solution of the DEP algorithm leads to a discrete Lie-Poisson algorithm. As an application, a reduced symplectic integrator for two dimensional hydrodynamics is constructed.

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MS04

Finite Symmetry Methods for N Identical Vortices on the Sphere

I will describe joint work with Mark Roberts and Chjan Lim, in which we use the actions of both the rotation group and the permutation group to prove the existence of many relative equilibria for systems of identical point vortices on the sphere. The symmetry types of the relative equilibria can be used to block-diagonalize the hessian of the augmented Hamiltonian so simplifying the stability calculations. Both 'direct' and time-reversing symmetries are used.

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MS04

Integrable Vortex Dynamics On A Sphere

We will describe the integrable structure of point vortices of arbitrary strength moving on the surface of a sphere. First, we will introduce the basic Hamiltonian structure, along with conserved quantities and an overview of the integrable three vortex problem. Then, we will focus on the geometry of three vortex collisions. Finally, we will describe the topology of streamline patterns on the sphere and the corresponding stereographic plane, whose Hamiltonian structure will be shown.

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MS05

Cargo Transfer with Shipboard Cranes: Control, Prediction, and Simulation

Ships with onboard cranes are used by the U.S. Navy and others to transfer cargo from larger ships to smaller ships for transport to shore. Rough seas can induce cargo pendulation and oscillation of the landing platform, making operations using existing control mechanisms infeasible. I will give an overview of work by the Maryland Chaos Group on simulation of the dynamics, design modifications, and procedures for safe transfer and landing of cargo in moderately rough seas.

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MS05

Generating Random Numbers Via Deterministic Choas

A random number generator (RNG) based on a 2-regions 1D chaotic map is analysed, which overcomes the drawbacks of classical RNGs: inability to analyse and optimise the RNG, inability to compute probabilities and entropy of the RNG, and inconclusiveness of statistical tests. We exploit the deterministic part of the nature of chaos and the simplicity of the 1D map to extend existing works on chaos-based RNGs, and to give mathematical analysis of the information generation mechanism.

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MS05

Chaotic Dynamics and Modeling of Power System Loads

Electric arc furnaces are used in smelting and steel production. They also can cause significant degradations of electric power quality. This talk discusses the results of an interdisciplinary collaboration wherein ideas of nonlinear dynamics have been applied to model the operation of highly varying loads, such as electric arc furnaces, on power distribution networks. The analysis of associated time series is also discussed.

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MS05

Constructing Transportable Behavioural Models of Nonlinear Electronic Devices

We describe a new technique for producing transportable behavioural models of nonlinear electronic devices. The behavioural models are reconstructed using time domain input–output data. The models have the ability to accurately predict the response of an electronic device over a wide range of operating points. We demonstrate our methods using simulated data from an Ebers–Moll transistor acting as a simple amplifier.

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MS06

Ergodic Theory of Equivariant Diffeomorphisms

We describe recent work, some joint with Matthew Nicol (UMIST) on the stability of ergodicity and mixing for diffeomorphisms equivariant by a compact Lie group. This work extends earlier work of Field, Parry and Pollicott on stability of ergodicty for skew extensions and involves a natural extension of the concept of Markov partition.

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MS06

Ergodic Properties of a Class of Skew Products

Let M be a compact manifold on which a connected Lie group G acts. Suppose ϕ is a diffeomorphism of M which commutes with the G-action, such that the quotient diffeomorphism ϕ/G on M/G is sufficiently hyperbolic (Anosov, say). Consider perturbations $\tilde{\phi}$ of ϕ such that $\tilde{\phi}/G = \phi/G$. When G is compact, such perturbations are known to be 'stably ergodic' (Field–Parry, Burns–Wilkinson). We discuss similar results when G is non-compact.

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MS06

The Dynamics of a Class of Non-Uniformly Hyperbolic Attractor of Solenoid Type

We study the dynamics of a new class of strongly dissipative non-uniformly hyperbolic attractors which can be regarded as a natural extension of the Axiom A solenoid. The set of critical points is constructed and its dynamics are fully understood. As the source of the non-hyperbolicity of the given system, the set of critical points plays the same role as that of critical points in one-dimensional maps.

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MS06

Lyapunov Exponents and Partially Hyperbolic Systems

We discuss numerical experiments and results that show that nonzero lyapunov exponents can be created from systems with zero exponents almost everywhere. (Joint work with Mike Shub, Chaiwah Wu)

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MS07

Spatiotemporal Chaos in Electroconvection: An Application of Coupled CGL Equations

Recently, a direct transition from a uniform state to a state that exhibited spatio-temporal chaos was observed in electroconvection of the nematic liquid crystal I52 (M. Dennin, et al., PRL (1996); Science (1996)). Also, a weakly nonlinear analysis of the fundamental equations of motion has provided the relevant coupled complex Ginzburg-Landau equations for this system (M. Treiber and L. Kramer, PRE (1998)). This combination presents a unique opportunity to make quantitative comparisons between theory and experiment that will significantly increase our understanding of spatial-temporal chaos.

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MS07

The Complex Ginzburg Landau Equation: Connection to Physical Experiment

The complex Ginzburg-Landau (CGL) equation is widely used as a generic model for nonlinear traveling wave pattern formation. Other than qualitative features, what can a CGL description say about the *quantitative* behavior of real physical systems? I will present experimental results for a traveling wave wall mode in rotating Rayleigh-Bénard convection which demonstrates the utility of the CGL equation

in accurately predicting experimental behavior.

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MS07
Long Wavelength Behavior in the 1D Complex Ginzburg-Landau Equation

Previous work suggests replacing chaotic fluctuations with a noise term in long wavelength descriptions of spatiotemporal chaos. We demonstrate that the behavior of the chaotic 1D complex Ginzburg-Landau equation exhibits a crossover similar to that of the Kardar-Parisi-Zhang (KPZ) Langevin equation. Using large-scale computations we measure the KPZ coefficients as a function of system paramters and find that they agree well with our estimates based on simple scaling arguments.

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MS07
Transition from Ordered to Disordered Defect Chaos

In numerical simulations of coupled complex Ginzburg-Landau equations describing parametrically excited waves we find a transition from a disordered to an *ordered* state of spatio-temporal chaos. While in the disordered chaotic state the defects in the wave pattern seem to perform a random walk, their dynamics are strongly correlated ('bound pairs') in the ordered chaotic state and the waves maintain an ordered stripe pattern. This is reflected in various spatio-temporal statistics of the defects.

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MS08
Snaking Curves of Multibumps, Degenerate Hamiltonian Hopf Bifurcation and Cellular Buckling

Subcritical (nonintegrable) Hamiltonian-Hopf bifurcations are known to cause an infinity of multi-bump homoclinic orbits which have application in elastic buckling and to nonlinear waves. We consider a fourth-order Hamiltonian system with competing nonlinearities. Here the local bifurcation can become degenerate leading to a heteroclinic tangle. The ensuing snaking bifurcation curve may be used to describe the repeated localised buckling of a long structure cell by cell.

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MS08
The Saddle-Focus Induced Homotopy Classes and Their Action Minimizing Orbits for Hamiltonian Systems With Two Degrees of Freedom

By the classical result of M. Morse, every homotopy class of curves on a closed surface of genus greater than one contains a length minimizing geodesics. We shall explain how this principle can be adapted to explore the action-minimizing solutions of (non-mechanical) Hamiltonian systems with two degrees of freedom that exhibit saddle-focus equilibria. Our primary example is the extended Fisher-Kolmogorov equation, $u'''' - \beta u'' + u(u^2-1) = 0$, investigated in a joint research with W.D. Kalies, J.B. VandenBerg, and R.C.A.M. VanderVorst.

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MS08
An Elliptic Equation with Spike Solutions Concentrating at Local Minima of the Laplacian

We examine a singularly perturbed equation that arises when one looks for standing wave solutions of the nonlinear Schrödinger equation. The equation contains a coefficient function. We find solutions that decay at infinity and concentrate near local minima of the function. Unlike in previous results, the minima may occur in unbounded components, and therefore are not "topologically stable" in the way that a strong local extremum or a saddle point is.

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MS09
Bifurcations of Localized Structures in Lattice Systems

We demonstrate the scenarium showing how the stable spatially localized solutions with nontrivial dynamics may appear in lattice dynamical systems. Bifurcations to such regimes occur when the strength of spatial interactions exceeds some threshold. Therefore these regimes were indeed created by spatial interactions rather than the ones existing as well in the lattices of noninteracting maps. Our approach can be applied to study bifurcations to nonstationary states with spatial structure of general type.

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MS09

Collective Behavior of Lattices of Strongly-Coupled Chaotic Maps

Strongly-coupled chaotic map lattices exhibit non-trivial collective behavior. Their macroscopic dynamics becomes universal (similarly to single maps) in the continuous-space limit which arises from a renormalisation group approach. We briefly recall these facts before presenting a simple model, valid in all space dimensions, without any free parameter, which accounts well for the collective motion by reducing the dynamics of the system to a one-body distribution function coupled to a coherence length.

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MS09

Symmetry and Control of Extended Dynamical Systems

The problem of controlling spatiotemporally chaotic dynamics of systems modeled by coupled map lattices is considered. Using linear stability analysis it can be shown that symmetry of the lattice plays a very important role in the problem and that the geometry of control is closely related to the geometry of the system itself. A scalable distributed control approach is introduced and the implications of theoretical results for actual experimental systems are discussed.

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MS09

Existence, Uniqueness, and Smooth Dependence of Thermodynamic Limits of SRB-measures

We show that there exists a unique thermodynamic limit of SRB-measures over a weakly coupled hyperbolic map lattice. This limit has the usual properties of an SRB-measure. It can be represented as a Gibbs state of a higher dimensional lattice spin system of equilibrium statistical mechanics and it has a potential function with zero topological pressure. It depends smoothly on the coupled map lattice in suitable functional spaces.

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MS10

Time-Stepping Algorithms with Controllable High-Frequency Dissipation for Nonlinear Dynamics

We introduce a new family of time-stepping algorithms for nonlinear dynamics that exhibits a controllable numerical dissipation in the high-frequency. The main motivation behind these methods is the elimination of the error associated with the approximation of the high-frequency spectrum of continuous systems. A complete analysis of these methods will be presented, illustrating the treatment of other properties of the continuum problem (like conservation laws, associated momenta, etc). Representative numerical simulations in the context of the finite element method in elastodynamics will be also presented.

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MS10

The Post–Processed Galerkin Method Applied to Nonlinear Shell Vibrations

We present the results of a computational study of the post–processed Galerkin method applied to the von Karman equations governing the motion of a thin cylindrical panel periodically forced by a transverse point load. We spatially discretize the shell using finite differences to produce a large system of ODEs and construct "flat Galerkin", "nonlinear Galerkin" and "post–processed Galerkin" schemes for approximating the solution of the ODEs. We find the post–processed Galerkin scheme to be most efficient.

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MS10

Geometric Exact Models, Energy-Momentum Methods, and Active Degrees of Freedom for the Dynamics of Shells and Rods

In various fields of applications, thin bodies are considered by means of one or two dimensional models, the so called rod or shell theories which are achieved as dimensionally reduced formulations of three-dimensional continua. The paper is concerned with: (1) The formulation of one-dimensional models of spatial rods as well as two-dimensional models of shells. (2) The finite element modelling of the nonlinear dynamics including finite deformations and chaotic motion. (3) The construction of stable energy-momentum integration schemes for long time simulations of such large systems. (4) Determining the active degrees of freedom of such models in order to apply the postprocessed Galerkin method to approximate inertial manifolds (in case they exist) for a possible dimension reduction of the dynamics of shells and rods using the finite

element method.

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MS10

Nonlinear Oscillations of a Fluid Conveying Tube with an End Mass

We investigate the three-dimensional dynamics of a fluid conveying tube with an end mass. In an experimental setup Moon and Copeland observed several oscillatory states, which differ from the pure plane and rotating waves predicted as primary solutions in rotatory symmetric systems. Using equivariant bifurcation theory and path following methods we relate some of these observed states to branches generated by higher order bifurcations.

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MS10

Postprocessing Galerkin Methods

In this talk we will present a Postprocessing Procedure of the Galerkin method which involves the use of an approximate inertial manifold to model the high wavenumbers component of the solution in terms of the low wavenumbers. This postprocessed Galerkin method, which is much cheaper to implement computationally than the Nonlinear Galerkin (NLG) Method, possess the same rate of convergence (accuracy) as the simplest version of the NLG, which is more accurate than the standard Galerkin method. Our results valid in the context of spectral and finite element Galerkin methods and for many nonlinear parabolic equations including the Navier-Stokes equations. We will also present some computational study to support our analytical results.

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MS11

Communicating with Chaos

In this lecture, I will argue that we can utilize the close connection between the theory of chaotic systems and information theory to encode any desired message in an experimental chaotic signal and thereby use this signal as a communicaton source. I will show a movie in which this experimental encoding is done in real time.

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MS11

Communicating With Chaos Using Two-Dimensional Symbolic Dynamics

Symbolic representations of controlled chaotic orbits can be used for communicating. We investigate communicating with chaos by using more realistic dynamical systems described by three-dimensional flows. It is difficult to specify a generating partition so that a good symbolic dynamics can be defined. A solution is proposed whereby hyperbolic chaotic saddles embedded in the attractor are exploited for digital encoding. Issues addressed include channel capacity and noise immunity when using these saddles for communication.

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MS11

Redundant Chaotic Signals

The intrinsic redundancy of controlled chaotic signals make them natural information carriers. A technique will be presented showing that this property can be used to reconstruct extensive amounts of missing parts to the chaotic signal. It also significantly improves the information capacity of the communication channel.

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MS11

Communication with Chaotic Waveforms

We review recent progress in the field of communication with chaotic optical systems and report the results of experiments with erbium doped ring lasers and optical fiber communication channels. The dynamics of these lasers are described by coupled delay-differential equations. The processes of message encoding and recovery with appropriately designed transmitters and receivers will be described.

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MS12

The Topology of Explosions: Sudden Appearance of Recurrent Points

A crisis is a sudden jump in the size of a chaotic attractor.

More generally, we call the discontinuous bifurcation of a component of the chain recurrent set, such as a chaotic saddle or attractor, an "explosion". We show that for a large class of planar maps, an explosion implies the existence of a homoclinic or heteroclinic tangency.

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MS12

Topology of One-Dimensional Tilings

Given a finite collection of one-dimensional "proto-tiles" (closed intervals), an inflation constant, and a substitution rule that expresses each inflated proto-tile as a union of proto-tiles laid end to end, there is an associated space of all permissible tilings of the real line with a natural topology. With mild assumptions on the nature of the substitution, we will show that if two such tiling spaces are homeomorphic then their associated substitution matrices are weakly equivalent.

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MS12

Topological Horseshoes

When does a map have chaotic dynamics in a closed set? More specifically, when does the map admit an invariant set in the closed such that the map restricted to that invariant set factors over the shift on m-symbols or a subshift of finite type? This work is an attempt to clarify some of the issues when no hyperbolicity is assumed. We then demonstrate some examples, including billiards, where our conclusions apply.

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MS12

Topological Phenomena in the 3D Single Crystall Normal Metals

The motion of quantum electrons along the Fermi Surfaces in the strong magnetic field leads to the nontrivial problems in the theory of Dynamical System and 3D Topology. Universal behavior of conductivity in the strong magnetic field was found. The observable integer-valued Topological Quantities of the new type are predicted.

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MS13

Dynamic Control of Cardiac Alternans

A dynamic control technique was used to suppress a cardiac arrhythmia called an alternans rhythm in a piece of dissected rabbit heart. Our control algorithm adapted to drifting system parameters, making it well-suited for the control of physiological rhythms. Control of cardiac alternans rhythms may have important clinical implications since they often precede serious cardiac arrhythmias and are a harbinger of sudden cardiac death.

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MS13

Using Control Blindly to Find Unstable Periodic Orbits

Biological experiments have employed Proportional Perturbation Feedback (PPF) control to stabilize periodic orbits. PPF control is based on the idea of placing the system's state on a stable manifold, but, I'll show, can be successful even without a stable manifold. In fact, PPF control can be used blindly, without knowing where there is a periodic orbit and may serve as a general experimental technique for studying excitable biological systems.

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MS13

Shedding Light on Neuronal Dynamical "Dark Matter"

Unstable periodic orbit (UPO) structure has been identified within neuronal systems. A striking feature of such UPO analysis has been the gaps of time within which no UPOs are resolvable - dynamical "dark matter". Since UPO extraction methods frequently assume that the underlying dynamics are differentiable, it is necessary that the functions be continuous. Periods of observed differentiability should be fully contained within periods of continuity.

We prove this is the case for a neuronal network.

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MS13

Cross-Spectral Analysis of Tremor Time Series

We apply cross-spectral analysis to tremor time series and related signals. For the physiological tremor, analysis of the muscle activity and the tremor time series shows that this tremor is a resonance phaenomenon and that the measured muscle activity represents a Newtonian force acting on the hand. For enhanced physiological tremor a statistical test for the contribution of reflexes is derived. An analysis including the EEG reveals the contribution of cortical activity to certain tremors.

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MS14

Characterizations of Natural Patterns

Textured patterns are created via spontaneous symmetry breaking and exhibit "configuration independent" characteristics. A class of measures called the "disorder function", $\bar{\delta}(\beta)$, will be introduced to describe such features. Analysis of patterns shows that $\bar{\delta}(\beta)$ is identical for multiple patterns generated under fixed external conditions. The relaxation of patterns from initially random states can be quantified using the time evolution of $\bar{\delta}(\beta)$. The creation of domains and their coarsening are shown to exhibit different characteristics.

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MS14

Controling Turbulence by Global Feedbacks

Global delayed feedbacks are introduced into the complex Ginzburg-Landau equation. Their influence on diffusion-induced turbulence described by this equation is investigated by numerical simulations. We show that turbulence can always be suppressed by adjusting the feedback inensity and the delay time. In the presence of feedbacks, new types of spatiotemporal patterns are observed that include localized turbulent bubbles, phase strings adn dynamical cellular structures

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MS14

Characterisation and Control of Spatiotemporal Systems

We present here a method to characterize and control spatially extended nonlinear systems by an analysis of invariant measures, *e.g.* Lyapunov exponents, Lyapunov dimension, K-S entropy, in spatially localised regions. Variation of these invariant measures with increasing subsystem size shows interesting scaling relationship and reveals the existence of a critical subsystem size that may suffice in characterizing the full system dynamics. The method is quite general and works for both discrete and continuous dynamical systems.

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MS14

A Wavelet-Based Investigation of A Spatiotemporally Chaotic System

We investigate the nature of spatiotemporal chaos in the Kuramoto-Sivashinsky partial differential equation, showing with the aid of a wavelet decomposition that the relevant dynamical interactions are localized in space and scale. Three characteristic regimes of the dynamics may be identified: large scales of slow Gaussian fluctuations, active scales containing interactions of coherent structures,

and small scales. Motivated by this characterization, we construct low-dimensional, spatially localized models for a minimal "chaotic box".

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MS14

Periodic Orbit Analysis of High Dimensional Spatiotemporal Chaos

Motivated by low-dimensional periodic orbit theories, we compute hundreds of unstable periodic orbits (UPOs) and fixed points of the extensive chaotic Kuramoto-Sivashinsky (KS) equation. Using an escape-time weighting of UPOs, we are able to predict the long-time average spatial pattern of the KS equation, whereas trace formulas of UPOs are inapplicable. The error in the approximate average pattern scales as $O(1/N)$, where N is the number of computed UPOs and fixed points.

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MS15

Soliton Perturbations and the Random Kepler Problem

We consider a randomly perturbed Kepler problem. We reduce the problem, via an averaged Lagrangian approach, to a set of random ordinary differential equations. These are equivalent to a random Kepler problem. We calculate the Fokker-Planck equation governing the distribution of the soliton parameters. Using the action angle variables for the Kepler problem we are able to explicitly calculate the mean time to the destruction of the soliton in the weak noise limit.

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MS15

Shilnikov Manifolds in Coupled Nonlinear Schrodinger Equations

The forced-damped nonlinear Schrodinger equation (NLS) has been widely studied as a prototype of an infinite-dimensional near-integrable system that produces temporal chaos. In this talk we consider systems of coupled NLS equations and examine the origin of the spatio-temporal chaos observed numerically in such systems. We discuss single and multi-pulse homoclinic behavior and identify invariant manifolds resembling the shape of Shilnikov-type homoclinic orbits.

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MS15

Dynamics of Long Ring Lasers

Spatio-temporal dynamics of a pumped ring-cavity laser are modeled by the Maxwell-Bloch partial differential equations with spatially periodic boundary conditions. Simulations show regular and irregular behavior depending on the cavity length, pumping strength, material relaxation rates, and cavity losses. Irregular dynamics are unidirectional waves whose speed and height vary in a seemingly random fashion, but whose other features, such as the number of "crests" per spatial period, remain approximately constant in time. Computed power spectra, attractor dimension, and two-point correlation functions indicate the low-dimensional nature of the solutions. The existence of spatially-dependent orbits homoclinic to an unstable saddle-focus will also be discussed.

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MS15

Weak Turbulence with Applications to Semiconductor Lasers and Fiber Optics

Based on a model Hamiltonian appropriate for the description of many-body fermionic systems such as semiconductor lasers, we describe a natural asymptotic closure of the BBGKY hierarchy by analogy with that derived for classical weak turbulence. We find a new class of solutions to the resulting quantum kinetic equation which are analogous to the Kolmogorov spectra of hydrodynamics and classical weak turbulence. These solutions involve finite fluxes of particles and energy in momentum space and are particularly relevant for describing the behavior of systems containing sources and sinks. We explore these solutions by using differential approximation to the kinetic equation. We show that when these solutions are excited in semiconductor laser, the laser has lower lasing threshold and is more efficient. I will also present how the developed formalism can be applied to the problems in fiber optics telecommunications.

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MS16

Numerical Analysis of Dynamic Contact/Impact in Elastic Multi-Body Systems

We present new time-stepping algorithms for the integration of elastic multi-body dynamical systems that do not lead to an increase of the physical energy due to the contact interactions, thus leading to superior stability properties. In particular, the discrete frictional components preserve their physically dissipative character. We discuss the formulation and analysis of the newly proposed methods, as well as their numerical implementation in the context of the finite element method. Their performance is illustrated in representative numerical simulations.

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MS16

Variational Structure/Numerics of Contact Problems

The purpose of this talk is to analyze a variational formulation of problems involving contact and friction. Some numerical examples are done using the Coulomb model of friction to illustrate the method.

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MS16

Symplectic-Energy-Momentum Integrators

We shall discuss the theory and some simple examples of integrators for mechanical systems with symmetry that are symplectic (in a spacetime sense) as well as being mommentum and energy preserving. The basic methodology is to use adaptive time steps together with discretizations of the variational principle. The relationship of this work with other work of the authors on contact problems will also be discussed briefly.

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MS17

A Discrete Convolution Model for Phase Transitions

We study an Ising-like model for phase transitions, incorporating long-range interactions. The dynamics of the state is according to an gradient flow for the Helmholtz free energy. We construct traveling and stationary waves and give criteria for propagation and pinning of a wave. Some results concerning uniqueness and stability of the wave are given.

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MS17

A Variant of Newton's Method for the Computation of Traveling Wave Solutions of Differential-Difference Equations

We present a numerical method for finding traveling wave solutions to nonlinear bistable differential-difference equations using a standard BVP solver (*colmod*) through relaxation of the variational equation. Traveling wave solutions satisfy a two-point boundary value problem but standard BVP codes do not handle the discrete difference terms. Examples included demonstrate propagation failure, lattice anisotropy, bifurcation points in the wave speed and detuning parameter relation, and step-like solution profiles.

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MS17

Mosaic Solutions and Entropy for Spatially Discrete Cahn-Hilliard Equations

We consider a differential equation on a spatially discrete lattice which is analogous to the *Cahn-Hilliard* equation, but which need not be near a continuum limit. We prove existence of solutions for the *double obstacle* nonlinearity and consider the existence and weak-stability of *mosaic solutions*, which are equilibrium solutions which only take the values $+1$, -1 and 0 at each lattice point. Rigorous results are given for the spatial entropy of stable mosaic solutions.

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MS17

Crystallographic Pinning: Direction Dependent Traveling Waves in Higher Dimensional Lattices

We study traveling waves in networks of ODE's modelled on a high-dimensional lattice, and are interested in how wave speeds depend on the direction of motion. Crystallographic pinning occurs when a wave ceases moving in selected directions, and was examined in previous work with John Cahn and Erik Van Vleck for special systems. Here, we show how the phenomenon can be understood from general principles of dynamical systems.

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MS18

Nonlinear Evolution and Chaos in the Kelvin-Helmholtz Instability of High Velocity Anisotropic Shear Layers

The nonlinear instability of two layers of sheared compressible anisotropic plasma, which is important in astrophysics and geophysics, is studied under external driving. The solutions of the amplitude evolution equation derived for the marginally unstable regions using reductive perturbative methods are considered to obtain the parameter regimes where either a. the solutions evolve to final permanent wave patterns resembling empirically-observed vortex ensembles, or b. are disrupted by nonlinear modulational instability. A Melnikov function formulation for the problem is also developed, and reveals the existence of transverse homoclinic orbits leading to chaos.

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MS18

Onset of Chaos in Singularly Perturbed Systems

We consider a simple nonlinear system (a nonlinear oscillator) that undergoes a either singular perturbation or a discretization. Generically, the perturbed (discretized) system exhibits a chaotic behavior. For example, a homoclinic or heteroclinic connection do not survive the perturbation. We focus on the following problems: analytical description of breaking of homoclinic connections; breaking of periodic solutions: methods of approximation of perturbed dynamics including stable and unstable manifolds. Theoretically derived approximations are compared with actual dynamics.

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MS19

Modeling of Smectic A - Nematic Phase Transition

We develop the point of view that Smectic A liquid crystal configurations are periodic solutions of an extended nematic theory. We identify the physical mechanism responsible for the symmetry breaking of the nematic causing the nucleation of the smectic A phase. We compare the outcome of such modeling approach with the well-known theories of the smectic A–nematic phase transition due to Landau, de Gennes and Lubensky, for both, liquid crystals and superconductors. Flow induced transitions are also addressed.

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MS19

Viscoelasticity of Solutions of Semi-Flexible Polymers

Recent work on molecular models of viscoelasticity in solutions of semi-flexible polymers will be discussed. A tube model has been introduced to describe an isotropic 'tightly-entangled' regime in which the polymers are confined to tubes of diameter much less than the persistence length, whose predictions are compared to experiments on solutions of actin protein filaments. Initial results for the linear response of nematic solutions will also be discussed.

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MS19
Kinetic Models of Polymer-Liquid Crystal Systems

I will present a kinetic theory for the blend of ridgid rod polymers and flexible polymers that account for the Brownian motion, excluded volume and entanglement effects. Solutions in various conditions will be discussed.

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MS19
Direct Numerical Simulation of Nematic Textures: Phase Transitions and Shearing Flows

This work will present the computational modeling of nematic liquid crystalline texture that arise during the nematic-isotropic phase transitions and during and after shearing flows. Quantitative descriptions of defect densities, coarsening, global and local orientation correlation functions and light scattering will be presented. The fundamental principles that govern topological processes in defect nucleation and coarsening processes during shearing flows will be presented.

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MS20
Stabilizing and Destabilizing Effects of Dissipation on Manifolds of Relative Equilibria

In Hamiltonian systems with symmetries, relative equilibria often come in families, parametrized by the momentum map of the symmetry group. If alongside the Hamiltonian structure also a weak dissipation is present, then, in general, the momentum map is dissipated and the relative equilibria are not preserved, even modulo symmetries. However, the family consists of relative equilibria with different values of the momentum map, so the family can persist. Criteria which determine stability or instability of such persistent families will be given in this talk.

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MS20
On Relative Normal Modes

We generalize the Weinstein-Moser theorem on the existence of nonlinear normal modes near an equilibrium of a Hamiltonian system to a theorem on the existence of relative periodic orbits near a relative equilibrium in a Hamiltonian system with continuous symmetries. In particular we prove that under the appropriate hypotheses there exist relative periodic orbits near relative equilibria even when these relative equilibria are singular points of the corresponding moment map, i.e., when the reduced spaces are singular.

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MS20
Mechanics on Homogenous Spaces

When one investigates mechanical systems with symmetry on tangent and cotangent bundles, the group orbits in the configuration space will be immersed homogeneous spaces. Thus a component in the understanding of these systems will be an understanding of mechanical systems whose configuration space is a homogeneous space. In this work we study these latter systems, and our approach is to derive dynamics on a "minimal" smooth manifold (minimal meaning "with small symmetry group").

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MS20
Bifurcations from Symmetric Relative Equilibria

Symmetric states play a central role in the analysis of steady motions. The identification of steady motions through a series of symmetry breaking bifurcations from some highly symmetric, and hence easily determined, 'trivial' solutions is a very successful strategy. However, isotropy complicates much of the modern geometric framework for Hamiltonian systems. A 'retro' approach, guided by the modern theory, yields an efficient analysis of systems with and without isotropy, including infinite dimensional problems.

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MS21
Controlling and Synchronizing Space Time Chaos

Control and synchronization of extended systems is realized with a finite number of local tiny perturbations, which linearly scales with the size of the system. These perturbations are able to restore each desired unstable patterns, as well as to synchronize two space time chaotic states. The effectiveness and robustness of the method are shown for the amplitude and phase turbulent regimes of the one dimensional Complex Ginzburg Landau equation.

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MS21

Visualization, Identification and Control of Chaos in Biological Systems

The identification of chaos in biological and physical systems helps us to understand and possibly control previously intractable problems such as deadly heart arrhythmias (fibrillation) and seizures in the brain. It is the purpose of this talk to introduce the basic tools for understanding, analyzing and controlling chaos in biological systems with an emphasis on the basic principles involved and recent work on controlling atrial fibrillation in humans. Results will also be presented on the high speed, high resolution visualization of ventricular fibrillation in heart experiments.

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MS21

Influence of Noise on Control of Chaotic Lasers

Experimental studies of control of chaotic lasers showed that control is very difficult to achieve in some operating regimes. We examine time series from different types of laser operation and investigate the influence of noise on the dynamics of the laser [1]. A comparison of experimental results with numerical simulations will be given.

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MS21

Nonlinear Prediction, Filtering and Control of Chemical Systems from Time Series

Advances in controlling dynamical systems, stimulated in recent years by the challenge of chaotic dynamics, have been largely based on the development of linearized models from time series. We present an approach for nonlinear prediction, filtering and control based on the construction of appropriate nonlinear hypersurfaces directly from time-series readings. A three variable model for chemical chaos is used to demonstrate the approach.

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MS22

Synchronization of Pulse-Coupled Oscillators with Delays

We show how a synchronized network of integrate-and-fire neural oscillators with non-instantaneous interactions can destabilize in the strong coupling regime due to a discrete Hopf bifurcation in the firing times. This leads to non-phase-locked behaviour in which the inter spike intervals exhibit periodic or quasiperiodic variations on closed invariant circles. The latter can support several distinct types of behavior including mode-locked bursting states and oscillator death. In the case of a spatially extended network, the invariant circles are separated in phase space resulting in a spatially periodic pattern of mean firing-rate across the network that is modulated by deterministic fluctuations of the instantaneous firing-rate.

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MS22

Population Coding and Noise Shaping in Spiking Neurons

Neural information is generally thought to be carried by the firing times of neurons which are often noisy and irregular. If a network of neurons is firing asynchronously, one possible method of encoding analog information into discrete firing times is to consider the average of the population. For uncoupled neurons, averaging will only reduce the noise amplitude by the square root of the number of neurons N. Borrowing a concept known as noise shaping from electronic analog-to-digital conversion, I will describe a network coupling scheme which can reduce the noise amplitude faster than root N over a given frequency band.

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MS22

Dynamics of a Solid-State Laser with Injection

The mathematical analysis of phase locking in lasers is usually studied in the limit of weak forcing and detuning, where the dynamics reduce to a simple phase equation. But in an intermediate parameter regime, the behavior becomes more subtle. Unlocking occurs via a novel bifurcation scenario that combines supercritical Hopf and saddle-node infinite period bifurcations. This scenario (which probably occurs in other systems) obeys scaling laws that will be explained heuristically.

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MS22

Small Worlds –The Dynamics of Networks Between Order and Randomness

The small-world phenomenon is familiar to us through folklore and anecdote – everyone on earth is connected via only a short chain of mutual acquaintances. Here I show that the small-world phenomenon is actually a property of a general class of partly-ordered, partly-random graphs.

These "small-world networks" can be used both to characterize the structure of real networks (as diverse as movie actors, power grids and nervous systems), and also as a framework for exploring the relationship between network structure and the dynamics of distributed systems.

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MS23

Fast Singular Oscillating Limits of Stably Stratified Three-Dimensional Euler-Boussinesq Equations

The 3D rotating Boussinesq equations (the "primitive" equations of geophysical fluid flows) are analyzed in the asymptotic limit of strong stable stratification. The resolution of resonances and a non-standard small divisor problem are the basis for error estimates for such fast singular oscillating limits. Existence on infinite time intervals of regular solutions to the viscous 3D "primitive" equations is proven for initial data in H^{α}, $\alpha \geq 3/4$. Existence on a long time interval T^* of regular solutions to the 3D inviscid equations is proven for initial data in H^{α}, $\alpha > 5/2$ ($T^* \to \infty$ as the Froude number $\to 0$).

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MS23

On the Algebra of the Curl Operator for Euler and Navier-Stokes Equations

We present new results on the algebra of the *curl* operator for 3D Euler equations and generalized conservation laws. New estimates for solutions of 3D Navier-Stokes equations are derived.

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MS23

Geometric Approximation Methods in Ocean Modeling

A 3D fluid equation for geodesic motion on the diffeomorphism group, with respect to the H^1 metric derived in the framework of the Euler-Poincar/'e theory, by applying asymptotic expansions, two-timing and averaging in Hamilton's principle for an ideal incompressible fluid. A new closure model for turbulence in pipes and channels based on a viscous version of this equation. Comparison with experimental data. Applications of this approach in ocean and atmosphere dynamics.

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MS24

Well Posedness and Ill Posedness for the IVP of Nonlinear Dispersive Equations

In collaboration with Carlos E. Kenig and Luis Vega, we study the problem of the minimal regularity of the data which guarantee that the IVP for some dispersive model are well posed. These models include the 1D cubic (focusing) Schrodinger equation, the KdV and the modified KdV equation. Among other results we prove that the problems are ill posed in Sobolev spaces with index above those suggested by the scaling.

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MS24

The Evolution of Compactly Supported Planar Vorticity

The evolution of ideal incompressible fluid vorticity preserves compactness of support. For planar fluids, the diameter of the support of nonnegative initial vorticity will be shown to grow no faster than $\mathcal{O}[(t\log t)^{1/4}]$, improving the bound of $\mathcal{O}(t^{1/3})$ obtained by Marchioro. In addition, an example of an initial vorticity with indefinite sign will be given whose support grows unboundedly at a rate of $\mathcal{O}(t)$.

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MS24

Emergence of Channelized Drainage Patterns and Landsurface Scalings

The evolution of channelized surface flows is characterized

by four phases: initial exponential growth of disturbances; emergent channelized flows; emergent separable solutions with orderly flows; and final dissipation of the surfaces. Polynomial scalings of 0.5 in the autocorrelation functions of water that emerge in the second phase suggest random initial controls while a later scaling of approximately 0.7 in the eroding surface is related to a dynamic scaling condition and transient (similarity) attractors.

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MS25

Probing the Microscopic Chaos of a Fluid of Particles With a Brownian Test Particle

Experimental evidence for microscopic chaos has recently been reported [P. Gaspard, M. E. Briggs, M. K. Francis, J. V. Sengers, R. W. Gammon, J. R. Dorfman, & R. V. Calabrese, Nature **394**, 865 (1998)]. In this experiment, the characterization of Brownian motion has provided a lower bound on the Kolmogorov-Sinai (KS) entropy per unit time of the many-body dynamical system composed of the colloidal particle and of the surrounding water molecules. For this system, the connections between the measured n-time probabilities, the dynamical entropies, and the spectrum of Lyapunov exponents are discussed.

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MS25

Multifractal Phase Space Densities for Stationary Nonequilibrium Systems

Computer simulations reveal that the phase space density of a classical system in a nonequilibrium steady state collapses onto a multifractal attractor with an information dimension less than the dimension of the phase space. Such steady states are usually generated by adding energy-constraining forces to the equations of motion, which remain strictly time reversible. However, the phase flow is macroscopically irreversible in accordance with the Second Law. It is shown that the multifractal structure persists if the time-reversible constraint forces are replaced by stochastic boundaries such that the flow is equivalent to a random map.

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MS25

Time Reversibility, Entropy Balance, and the Green-Kubo Relations

More than 60 years ago baker maps were introduced by Hopf to illustrate ergodic behavior and the relaxation to thermodynamic equilibrium in closed systems. We generalize these maps to model transport in open systems. The balance equation for the thermodynamic entropy is derived, shedding new light on the notion of reversibility in non-stationary states. Subsequently, fluctuations of the entropy production in steady states are addressed, leading to a novel derivation of the Green-Kubo relations.

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MS25

Hyperbolicity and KAM Bottles in the Driven Lorentz Gas

We study the Lorentz gas with a constant external field and the Gaussian thermostat on a flat torus. In the numerical study of the system, Moran and Hoover (J. Stat. Phys. vol. 48, (1987) 709 - 726,) observed that for a strong external field a KAM stable periodic orbit may appear. We show analytically that this cannot happen if $k + < E, n >> 0$ where k denotes the curvature of a scatterer (it is positive for convex scatterers) and n is the outer unit normal vector on the boundary of a scatterer. This condition means that to avoid the locking of trajectories in a KAM "bottle" the scatterer must be curved strongly where the field E points inside it. Where the field points outside, the scatterer can be flat or even concave. We also give explicit conditions under which the system is hyperbolic, i.e. one of the Lyapunov exponents is positive and the other is negative (with respect to any invariant measure).

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MS26

Embeddings, Fractals and Making Sense of Digital Communications

This paper is about developing new Embedding Techniques which can be applied to digital signal processing. We shall suggest a natural extension of current digital communication channel models to include nonlinearity and reverberation. This leads to stochastic models involving iterated function systems. We shall discuss how time delay methods developed in dynamical systems theory for analysing experimental data can be modified and applied to this kind of channel.

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MS26
Projections, Embedding, and Fractal Dimensions

Think of an "attractor" reconstructed from experimental data as the image of the true attractor for the system under a (probably nonlinear) "projection" from a high- or infinite-dimensional state space to a low-dimensional "embedding space". What topological and metric properties do the true and reconstructed attractors share? I will discuss conditions under which one can or cannot prove that typical projections between the two spaces are one-to-one and/or preserve the fractal dimension of the attractor.

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MS26
Spurious Lyapunov Exponents in Attractor Reconstruction

Lyapunov exponents are among the most difficult invariants to determine from experimental data. In particular, when using embedding theory to build chaotic attractors in a reconstruction space, extra "spurious" Lyapunov exponents arise that are not Lyapunov exponents of the original system. The origin of these spurious exponents is discussed, and formulas for their determination are given.

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MS26
When Embeddings Perfectly Reflect the Dynamics

I will discuss conditions under which an embedding of a chaotic attractor from data is a diffeomorphism. Previously published conditions only guarantee that the embedding is one-to-one. This is joint work with J. Tempkin and T. Sauer.

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MS27
Stability and Dynamics of Vertically and Horizontally Shaken Sand

Shaking provides a simple mechanism to provide the energy needed to generate and to probe flows of granular materials. Tall layers of vertically shaken sand show a dazzling array of different states. Horizontal shaking results in a simple sloshing mode, plus a novel crosswise convective flow. A combination of both vertical and horizontal shaking provides a way to explore friction models. This talk will explore these aspects of shaking.

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MS27
Wave Patterns in Vertically Oscillated Granular Media

Thin layers of vertically oscillated granular media undergo a bifurcation to patterns of subharmonic standing waves at a critical value of the acceleration amplitude. Depending on the control parameters, squares, stripes, hexagons, or localized states (oscillons) are observed. Stripes undergo secondary crossroll and skew-varicose instabilities. These phenomena are quantitatively reproduced by molecular dynamics simulations, which additionally reveal that the velocity distributions for the grains are Maxwell-Boltzmann, and that convection rolls are driven by the wave motion.

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MS27
Energy Flows, Segregation, and Collapse in Vibrated Granular Media

We study vibrated granular media, investigating each of the three components of the energy flow: particle-particle dissipation, energy input at the vibrating wall, and particle-wall dissipation. Particle-wall interaction is often neglected, but can play an important role when the granular material is dilute. Situations with low agitation and strong dissipation lead to a collapse of the material, the density is rather large, and the observed particle-particle dissipation rate deviates from simple mean-field type predictions.

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MS28
Towards a Variational Principle for the Navier-

Stokes Equations

Variational methods represent a unique theoretical tool for producing rigorous inequality results relevant to fluid turbulence. Currently there are two seemingly unrelated approaches for extracting bounds on the energy dissipation in turbulence flows due to Howard & Busse, and Doering & Constantin. I will discuss how these may be interpreted as being *dual* to each other and how their unified whole can be generalised to yield *a* variational principle for the Navier-Stokes equations.

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MS28

Scaling and Burning Velocity in Turbulent Combustion

We investigate and compare the structure of level sets in two turbulent combustion models: reaction-diffusion KPP type equations and G-equation. It turns out that the structure of the level sets for these two models is significantly different. We use the estimate on the area of level sets for reaction- diffusion equation to obtain a non-rigorous upper bound on the turbulent burning velocity. We also obtain rigorous lower bounds for the burning rate in some situations.

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MS28

Dynamics and Blowup for an Active Scalar

We investigate the blowup of radial solutions of the Keller-Segel equations, which model chemotactic aggregation. We find that this system has a rich variety of solutions including multiple steady states, and multiple blowing up solutions that include a countable family of similarity solutions and a non self-similar solution. I will discuss the stability of the various solutions and also present some preliminary results on constructing a global phase-portrait for this system that encompasses all the different behaviors observed.

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MS28

Energy Dissipation Rate in Shear Driven Turbulence

We derive rigorous upper bound on the time averaged energy dissipation rate for shear driven turbulence based on the Navier-Stokes model for incompressible fluids. We extend earlier results of Doering and Constantin and obtain upper bound of the form $\frac{U^3}{L}$ for arbitrary shear driven turbulent flows where U is the typical length and L is the typical length of the flow. The upper bound agrees with Kolmogorov's heuristic estimate on energy dissipation rate for turbulent flows. Possible logarithmic corrections to the upper bound will also be discussed.

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MS29

Phantom Bursting in Pancreatic β-Cells

In pancreatic islets, β-cells normally produce a bursting pattern of electrical activity with a period of 10-30 sec. However, isolated cells exhibit high-frequency bursting (period 2-5 sec), or low-frequency bursting (period 1-3 min), or do not burst at all. We present a mathematical model that is capable of producing all three types of bursting. Normal islet bursting is produced by the interaction of two slow processes, neither of which has a 10-30 sec time constant, contrary to expectations. This is significant, since no biophysical process has been identified with the "expected" 10-30 sec time constant.

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MS29

Adaptation and Synchrony in Neural Oscillators

There is now good experimental evidence that cortical neurons make the transition from rest to repetitive spiking through a saddle-node bifurcation of a limit cycle. However, it has also been shown that this type of dynamics discourages synchronization between repetitively firing neurons. Most cortical regular spike units have slow currents that cause the firing rate to decrease. In this talk, I will show how these currents alter the synchronization properties of cortical neurons. I will also connect this work with recent results, both theoretical and experimental, on the transition from beta to gamma rhythms in cortical and hippocampal circuits. Bifurcation, formal reduction, and numerical methods will be employed.

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MS29

Neural Excitability, Spiking, and Bursting

We discuss a bifurcational mechanism of generation of action potentials (spikes) by biological neurons. We elaborate Hodgkin's classification and show that neurons from different excitability classes react differently to the same input. Class 1 neurons are always integrators whereas Class 2 neurons may be resonators or filters. We use geometrical bifurcation theory to extend existing classification of bursters to include more than 20 new types.

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MS29

Propagating Activity Patterns in Thalamic Networks

Synaptically coupled neuronal networks can exhibit a wide variety of propagating wave activity. These waves depend on many network properties including whether the coupling is excitatory or inhibitory and the topology of the synaptic footprint. In this talk, I will discuss how geometric singular perturbation methods have been used to determine when the waves exist, compute the wave speed, and determine bifurcations of the waves as parameters are varied.

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MS30

Periodic Orbits in Singularly Perturbed Systems

A general construction of periodic orbits for fast/slow systems due to Soto-Trevino will be described. A new type of "jumping" periodic orbit will be shown to exist in a forced, damped equation modelling the motion of the planet Mercury. The construction uses an adaptation of the Exchange Lemma for tracking invariant manifolds

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MS30

Surface Nucleation of Superconductivity

A superconductor placed in an applied magnetic field will change its state. When the applied field is strong enough, then it penetrates the sample and the material is in the normal state. When the field is reduced to a critical value H_{C_3} called the upper critical field, the normal state loses stability and superconductivity nucleates. In this talk we give estimates of the value of $H_{C_3}(\kappa)$ for a bounded superconductor with arbitrary shape and with large value of the Ginzburg-Landau parameter κ. We also study the location of nucleation and the behavior of the order parameter when the applied field is close to the upper critical field. It is interesting to us that the curvature of the sample plays an important role in the nucleation phenomenon. The results presented in this talk are obtained jointly with Kening Lu at Brigham Young University.

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MS30

On Reaction-Diffusion Systems with Strong Coupling

We consider some reaction-diffusion systems (including Gierer-Meinhardt system and Gray-Scott model) in R^2. If one diffusion coefficient goes to zero and the other one goes to ∞, one obtains the so-called shadow system which has been studied by numerous authors. Here we assume one diffusion coefficient goes to zero and the other one is finite. (This is strong coupling case.) We first establish the existence of single and multiple spiky solutions for the stationary system of elliptic equations. Then we show that these solutions are weakly metastable. Finally we consider the motion of two weakly interacting spikes in R^2.

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MS30

Homoclinic Orbits for Singularly Perturbed NLS

Consider the perturbed NLS

$$iu_t = u_{xx} + 2(|u|^2 - \omega^2)u + i\epsilon(u_{xx} - \alpha u - \beta),$$

where u is periodic and even in x. We prove that there exist homoclinic orbits when $\epsilon > 0$ is small.

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MS31

Levy-Stable Distributions and Self-Similar Teletraffic Modelling

Recent work in teletraffic analysis across a range of network types has provided evidence of statistically self-similar behaviour in the traffic on real networks. This work will report some studies on a variety of teletraffic types, the development of suitable models based on Levy-stable distributions and disucss the impact of such characteristics on call admission control schemes.

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MS31

Codes for Spread Spectrum Applications Generated With Chaotic Dynamical Systems

The channels used in digital telephony have the capacity to carry many conversations simultaneously, but if one naively superposes the various signals the result is not simultaneous communication, but babble. The solution is to encode speakers so that their separate voices can later be disentangled. We explain how to construct such codings using an analogy between code-words having desirable correlation properties and time series of measurements from certain dynamical systems—those with Lebesgue spectrum.

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MS31

Chaos, Communications and Nonlinear Data Analysis

Potential applications of chaotic dynamics in communication systems are explored. In particular, we discuss the application of nonlinear noise reduction methods for implementing robust information channels. Different noise reduction algorithms are compared which are based on different pre-knowledge about the underlying dynamics. Furthermore, classes of dynamical systems are presented which turned out to be most suitable for applications in communication systems.

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MS31

Improving the Robustness of Synchronised Chaotic Communication Systems

Chaotic communication systems potentially offer some advantages over conventional systems. However, while some techniques show some promise, many proposed systems show little, if any, robustness to channel noise and distortion. Bandwidth efficiency is also rarely considered. This is particularly true for self-synchronised systems, and while some methods to compensate for channel distortion exist, they tend to have limited applicability. This paper discusses techniques to improve the robustness of information transmission, while also retaining bandwidth efficiency.

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MS32

Classifying Excitable Reaction-Diffusion Systems

The dynamics of extended systems near primary bifurcations can be modelled by amplitude equations. Excitable dynamics cannot be described by such local perturbative theories, yet the ubiquity of some behaviors is an indication that a classification is still possible. In this talk we present a classification of two variable excitable reaction–diffusion systems which is mainly based on the underlying homogeneous dynamics. Some particular applications will also be discussed.

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MS32

Frequency Locked Patterns in a Periodically Perturbed Reaction-Diffusion System

Frequency locking has been well studied for driven nonlinear oscillators, yet little is known about the shape and content of the Arnol'd tongues of locking for spatially extended systems. We present experiments which examine the effect of periodic optical perturbations on a light-sensitive oscillatory chemical reaction-diffusion system. Transitions from spiral traveling wave patterns to various frequency locked standing wave patterns are observed. Numerical simulations of a reaction-diffusion model yield qualitatively similar phenomena.

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MS32

Topological Structure of Noise Driven Excitable Systems

It is possible to describe deterministic flows from a topological perspective, studying the organization in phase space of periodic solutions. Noisy excitable systems present complex behaviour, usually studied from a statistical point of view. In this communication we show how to perform a topological analysis of this problem. The extension of the techniques to describe the topology of three dimensional flows to noisy systems allows us also to study higher dimensional deterministic flows.

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MS32

Excitable Behavior in Semiconductor Lasers

We experimentally investigate the dynamical behaviour of semiconductor lasers with feedback. We show that the noise plays an important role close to the instability threshold, anticipating the appearence of a regime called "Low Frequency Fluctuations". We claim that the Andronov bifurcation is at the origin of this dynamical regime.

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MS33

The Motion of The Bubble Towards The Boundary

We establish for the Cahn-Hilliard equation that small bubbles in the interior move towards the closest point on the boundary.

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G. Fusco

G. Karalis

MS33

Multi-Spike Solutions to the Cahn-Hilliard Equation

This represents joint work with Giorgio Fusco. Let f be a bistable nonlinearity (such as $u - u^3$). We consider multi-peaked stationary solutions to the Cahn-Hilliard equation $u_t = -\Delta(\epsilon^2 \Delta u + f(u))$ in Ω, $\frac{\partial u}{\partial n} = \frac{\partial \Delta u}{\partial n} = 0$ on $\partial\Omega$ with the average value of u in the metastable region. By "multi-peaked" we mean states which, as $\epsilon \to 0$, tend to a constant value everywhere except for a finite number of points in Ω, where the states tend to a different constant value. For any N we find such solutions with N peaks located at certain geometrically identified points. The ideas behind the proof come from a dynamical systems approach to PDE's.

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MS33

Cascades of Instability in The Solutions of Vector-Valued Cahn-Hilliard Equations

Vector-valued Cahn-Hilliard equations are studied. Simulations of phase separation show two remarkable events. First, the separation proceeds via a cascade of separations, i.e. the one-phase material undergoes separation into a two-phase material which may undergo separation into a three phase material. Second, between the separation events, the two-phase intermediate materials typically coarsen before the third material appears. In this talk, the simulations and an analysis of secondary phase separation will be presented.

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MS33

Pattern Formation in Gradient Systems

The Cahn-Hilliard equation is one of a large class of gradient systems in which stable or metastable patterns arise through the competition between a destabilizing and a stabilizing mechanism. There are many areas of science where such models arise. We examine such a class with the aim of establishing threshhold results for the appearance of patterns, as well as some of their properties.

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MS34

Stochastic Resonance and Neuron Firing; Statistical Aspects

No information is transmitted by a subthreshold signal. If noise is added, the signal plus noise sometimes exceeds the threshold and information is transmitted, but too much noise decreases detectability. This phenomenon is called stochastic resonance. We explore suitable measures of detectability, compute stochastic resonance surfaces in various parameters, and discuss application to some models of neuron firing. This is joint work with W. Wefelmeyer, U. Siegen, Germany, and L. Ward, Dept. Psychology, UBC.

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MS34

Current in Sharp Additive Ratchets: Analysis and Exact Results

We consider a one dimensional stochastic dynamics given by a first order differential equation driven by a telegraph process and standard Gaussian white noise. Such dynamics correspond to the Smoluchowski limit (high damping regime). The deterministic force is derived from a potential which is periodic with sharp barriers of equal height, but nonsymmetric with respect to its extrema. This system exhibits a steady state current, J, as a result of the asymmetry and the joint effects of the two types of noise. We study the dependence of the current on the diffusion coefficient, D, and the jump rate, γ, in the entire asymptotic regime of large and small values of these parameters. We find results quite different from those in the case of the smooth potential: here the current depends on fractional powers of the coefficient. We show that J is not a monotone function of the parameters (D, γ), and derive an analytical expression for how to maximize the current.

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MS34

Models and Prediction for Noisy Interface Dynamics

Metastable interface dynamics are characterized by periods in which the interfaces appear stationary, followed by a rapid transition to a new state. These dynamics can be strongly influenced by small noise. For several applications, we give the stochastic differential equations which model this effect. The time-dependent probability density, which quantitatively describes the dynamics and predicts the transition times, is obtained with a new asymptotic approach.

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MS34

A Combined Molecular Dynamics and Diffusion Model for Single Proton Conduction Through Gramicidin

Pomes and Roux have used molecular dynamics to calculate free energies for excess protons and for defects in the hydrogen bonding structure of waters in the pore of the ion channel gramicidin. Together with Pomes and Roux, the author has incorporated these results into a stochastic "framework" model for single proton conduction through gramicidin. Conductances predicted by the model are compared with experiment.

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MS35

Nekhoroshev-Stability of Elliptic (relative) Equilibria and the Riemann Ellipsoids

This talk presents some recent results on the classical problem of the stability of elliptic equilibria of Hamiltonian systems and their application to the study of the stability properties of relative equilibria, noticeably the so-called Riemann ellipsoids. The employed approach is based on the methods of Hamiltonian perturbation theory, particularly on Nekhoroshev's theory, which is capable of giving stability results for finite, but extremely long, times.

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MS35

Stabilization of Relative Equilibria

This talk will survey two methods of stabilization of relative equilibria in mechanical systems with symmetry. The first, due to Bloch, Leonard, Marsden and Sanchez focusses on modifying the kinetic energy of the system by a Kaluza-Klein construction and is intended for stabilizing balance systems. The second, due to van der Shaft, Marsden and Jalnapurkar, uses potential shaping along with external forces that can change the momentum map. We will propose how these two methods might be synthesized.

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MS35

Drift of Certain 4-vortex Relative Equilibria

Either in the plane or on the sphere, it is possible to arrange a relative equilibrium of 4 point vortices where 3 vortices of strength G stably rotate around a central vortex of strength of strength $-3G$ and where the moment of vorticity is zero. Here the symmetry group is $SE(2)$ in the planar case or $SE(3)$ in the case of the sphere; either way, zero is a nongeneric value for the momentum mapping and if perturbed these relative equlibria move about the plane or sphere. This talk will present aspects of the theory and numerics of this dynamics.

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MS35

A Generalization of Riemann's Theorem for Rotating Fluid Masses

This talk will describe joint work with Esmeralda Sousa Dias which generalises Riemann's theorem for the angular momentum and circulation vectors of an ellipsoidal relative equilibrium of a rotating fluid mass to sufficiently symmetric relative equilibria of any simple mechanical system with $SO(3) \times SO(3)$ symmetry. In particular we show that some 'pear-shaped' relative equilibria of rotating fluid masses satisfy the generalised theorem.

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MS36

From Generalized Synchrony to Topological Decoherence: The Decoherence Bifurcation

Transitions that occur as coupled systems are decoupled have been described in the literature in terms of the dynamics on the synchronization manifold. We describe a new transition, which we call the decoherence bifurcation, that is characterized by the creation of complicated sets off of the synchronization manifold. The proposed framework is applicable to non-identical coupled systems where symmetries are absent. We describe the transition and its dynamical consequences in several examples.

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MS36

Dynamics of Coding in Communicating with Chaos

A well chosen grammar leads to trajectories that live on a nonattracting but noise-resisting chaotic saddle embedded in a chaotic attractor. We find that the topological entropy of these chaotic saddles typically have a devil-staircase like behavior as a function of the noise resisting strength. Furthermore, there is usually a range of noise resistance in which the topological entropy decreases only slightly from that of the full chaotic attractor. The implication is that digital communication using chaos can yield a substantial channel capacity even in noisy environment.

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MS36

Calculating Topological Entropy with an Application to Communicating with Chaos

Motivated by recent work on communicating with chaos, we discuss numerical methods for evaluating the topological entropy of chaotic invariant sets, and in particular, invariant chaotic saddles formed by those points in a given attractor that never visit a forbidden gap region. Such gaps have been proposed as a means of providing noise immunity in schemes for communicating with chaos, and we discuss the dependence of the topological entropy on the size of the gap.

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MS36

Box-counting Dimension Without Boxes: Calculating D_0 from Average Expansion Rates

We propose an iterative scheme for calculating the box-counting (capacity) dimension of a chaotic attractor in terms of its average expansion rates. Similar to the Kaplan-Yorke conjecture for the information dimension, this scheme provides a connection between a geometric property of a strange set and its underlying dynamical properties. Our conjecture is demonstrated analytically with an exactly solvable two dimensional hyperbolic map and numerically with a more complicated higher dimensional non-hyperbolic map.

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MS37

Extended Geostrophic Euler-Poincaré Ocean Models

We consider the motion of a rotating, continuously stratified fluid governed by the hydrostatic primitive equations. Approximate Euler-Poincaré models (L1 and L2) for small Rossby number are derived for application to mesoscale oceanographic flow problems. Results of numerical experiments involving a baroclinically unstable oceanic jet show that the new L1 and L2 models give accurate solutions with errors substantially smaller than other balanced models.

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MS37

Successive Bifurcations in the Oceans' Wind-driven Circulation

The large-scale flow of the **mid-latitude oceans** is dominated by the presence of a larger, anticyclonic and a smaller, cyclonic gyre. The two gyres share the eastward extension of western boundary currents, such as **the Gulf Stream or Kuroshio**, and are induced by the shear in the winds that cross the respective ocean basins. The boundary currents and eastward **jets** carry substantial amounts of heat and momentum; the jets also contribute to **mixing** in the oceans by their "whiplashing" oscillations and the detachment of eddies from them. The low-frequency variability of this **double-gyre circulation**, for time-constant and purely periodic wind stress, is studied by the methods of nonlinear dynamics, analytically and numerically. **Symmetry-breaking bifurcations** occur, from steady to periodic and aperiodic flows, as wind stress increases or dissipation decreases. The first bifurcation is of **pitchfork** or perturbed-pitchfork type, depending on the model's degree of realism. Two types of oscillatory instabilities arise by supercritical **Hopf bifurcation**, with periods of a few months and a few years, respectively. Numerical evidence points to **hetero- and homoclinic** orbits that connect high- and low-energy branches of steady-state solutions. The results are compared with decade-long in situ and more recent, satellite **observations** of three ocean basins, the North and South Atlantic, and the North Pacific, and their significance for climate variability is discussed. This talk reflects collaborative work with K.-I. Chang (KORDI), H. Dijkstra (Utrecht), Y. Feliks (IIBR, Israel), K. Ide (UCLA), S. Jiang (MIT), F.-f. Jin (U. Hawaii), C. A. Lai (LANL), G. Loeper (ENS, Paris), Z.-g. Pan (UCLA), E. Simonnet (Paris Sud/Orsay), S. Speich (UBO/Ifremer, Brest), R. Tmam (Indiana U. & Orsay), & S. Wang (Indiana U.).

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MS37

Dynamical Systems Challenges in Assessing Ocean Transport

Recent developments in dynamical systems have afforded the application of geometric techniques to strongly time-dependent flows. These techniques can be used to determine the redistribution of fluid around coherent features, such as jets and eddies. Discussed will be joint work with Pratt and Miller on a study of circulation around an island. The fluid transport, and resulting vorticity budgets, associated with the dead zone off the eastern coast of the island will be determined. This will lead into a general discussion of the role of (eddy) viscosity, which is commonly used in (numerical) ocean models, in promoting transport of fluid particles and the implications for the transport of potential vorticity.

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MS37

Material Dispersion in Wind-driven Ocean Gyre

The prevailing winds on Earth drive basin-filling oceanic gyres in between the continents. These gyres are spatially inhomogeneous and turbulent. To characterize movement of matter in gyres, we integrate parcel trajectory equations, $\dot{\mathbf{x}}(t) = \mathbf{u}(\mathbf{x}, t)$ for an ensemble of initial placements, given a solution for $\mathbf{u}(\mathbf{x}, t)$. As a simpler alternative characterization, we assess the useful sill in an inhomogeneous, non-stationary stochastic trajectory model.

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MS38

Nonsmooth Bifurcations, Sliding Orbits and Their Application in Piecewise Smooth Dynamical Systems

We will discuss the role played by nonstandard bifurcations and other non-smooth phenomena in organising the dynamics of piecewise smooth systems. We will focus our attention to the occurrence of so-called border-collision and grazing bifurcations. After discussing a possible classification strategy, we will show how these bifurcations can lead to the formation of periodic orbits characterised by *sliding* sections (lying partly within the system discontinuity set). These orbits will be shown to organise "double-spiral" bifurcation diagrams describing the accumulation of periodic solutions, characterised by different number of switchings, onto a central sliding orbit. Applications to systems of

relevance in Engineering will be presented.

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MS38

Graph Theory, Probability and Many Dimensional Piecewise Smooth Dynamical Systems

In this paper we present a new method for the analysis of general piecewise smooth dynamical systems of arbitrary dimension, with particular reference to a model of impact dynamics in heat exchangers. We propose a hybrid method, linking graph theory and probability theory. This method enables us to classify and enumerate periodic solutions, construct a basis for the space of periodic solutions and to predict the exact nature of these solutions. Moreover, we are able to model the behaviour of the system as parameters are changed, and to show good agreement with experiments and numerical simulations.

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MS38

Analysis of Grazing Bifurcations in a Continuous and Piecewise Differentiable Friction Model

We investigate a recently proposed model of macroscopic friction, where the vector field is continuous, but has discontinuous derivatives across a border in state space. Several instances of localized bifurcation sequences are connected with near-grazing periodic orbits. We analyze these using *discontinuity mappings*. The results obtained show similarities with impacting systems, and are quite general for systems with a discontinuos first derivative in the limit of large discontinuity.

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MS38

Describing the Bifurcations of Piecewise Smooth Systems

Bifurcations of piecewise smooth dynamical systems can be studied via a type of linearization; that is, a piecewise linear map, such as a tent map in dimension 1. I will discuss the bifurcations that Helena E. Nusse and I observe for two-dimensional piecewise linear systems.

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MS39

Multifractal Spectra and Eigenfunction: What Determines the (Anomalous) Spreading of Wave Packets?

There is a variety of different quantum mechanical systems which exhibit multifractal spectra and/or eigenfunctions, including e.g. quasiperiodic Schroedinger equations, disordered systems and quantum Hall systems. It has been a question for quite some time, what generally determines the decay of correlations and the spreading of wave packets, that are found in numerical investigations. We show that for the class of systems which preserve the shape of the wave packet, its width increases as a power law in time. The exponent is given by the ratio of two multifractal dimensions, the dimension D_2 of the energy spectrum, divided by the dimension D_2 of the eigenfunctions. For the general case we show that this ratio is an optimum lower bound for the spreading exponent. Numerical results will be presented to illustrate these general results.

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MS39

Dynamics with Singular Continuous Spectra: Mechanisms and Renormalization Group Description

A short overview of spectral properties of dynamical systems with special emphasize on singular continuous spectra is given. Basic models demonstrating fractal spectra in dissipative systems (strange nonchaotic attractors) as well as in quantum mechanics (quasiperiodically driven spin-1/2 system) are described, and self-similar features of correlations and spectra are demonstrated. We show, how these self-similarities can be quantitatively described with the renormalization techniques based on symbolic description

of the process.

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MS39

Hidden Dimer in the Frenkel-Kontorova Model: Extended, Critical and Localized States in Quasiperiodic System with an Infinite Number of Steps

The incommensurability of the supercritical Frenkel-Kontorova model is decomposed into a family of *dimer* type "defects". The linear excitations of the system are then described by a tight binding quasiperiodic system with an infinite number of steps. The system exhibits resonace transitions where the *critical* fractal states of the model degenerate to the Bloch-type waves. In a generalized two-parameter model, the model exhibits localized states where the localization boundary interwines with the resonace transitions. In contrast to the rigerous results on the absence of localization in discrete quasiperiodic potential with *finite* number of steps, our study shows localization in a discrete quasiperiodic potential with an *infinite* number of steps.

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MS39

Dissipative And Hamiltonian Dynamics With Fractal Fourier Spectra: Symbolic Description And Multifractality

We discuss dynamical systems with singular continuous Fourier spectra: dissipative flows whose attractors contain saddle points, and Hamiltonian systems which describe steady planar flows of viscous fluids past arrays of eddies or solid obstacles. In both cases onset of fractal spectra is caused by singularities in the return (passage) times of the orbits. We provide a description of this phenomenon by means of self-similar symbolic sequences. A technique is proposed which yields exact values for certain generalized dimensions of multifractal spectral measures.

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MS40

Libration Orbit Missions: Historical Perspective and Future Applications

The Goddard Space Flight Center is at the cutting edge of technologies that support libration orbit mission design. Advances in mission design using invariant manifold theory, state-space equations for libration orbit control, and optimization based on eigenvector formulation to achieve constrained orbit parameters is discussed. A brief history detailing various missions — ISEE-3, WIND, SOHO, and ACE — is provided. These requirements are compared to those of upcoming missions like MAP, NGST and TRIANA.

David Folta
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MS40

Tools to Explore Liberation Point Orbits

Analytical and numerical tools to understand the phase space around the collinear libration points L1 and L2 are presented. The results given in terms of Poincare sections and semianalytical expansions are presented for simplified models of the Sun-Earth and Earth-Moon systems. The role of the stable and unstable manifolds of the objects in the center manifold for transfer problems (from Earth to libration orbit, and between libration orbits) and for station keeping strategies are shown.

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MS40

Heteroclinic Connections and Resonance Transitions in Celestial Mechanics

We apply dynamical systems techniques to the problem of heteroclinic connections and resonant transitions in the restricted three-body problem. These phenomena have been of concern to areas such as resonant capture of comets and trajectory design for newer missions, like Genesis. We show that the invariant manifold structures associated to libration points L_1, L_2 and the heteroclinic connections between their Liapunov orbits are fundamental tools that aid in understanding dynamical channels throughout the solar system.

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MS40

From Genesis to Armageddon

Genesis will be NASA's first mission to launch in the new millenium. It is also the first mission designed with dynamical systems theory, using the L1-L2 heteroclinic dynamics. The same dynamics contributes to the puzzling temporary-capture phenomenon of Jupiter comets, the famous groups and gaps in the Asteroid Belt, and the Near Earth Asteroid problem. This rich dynamics will enable new mission concepts like the New Grand Tour using the

symbolic dynamics of L1 and L2.

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MS41
Periodic Orbits in Re-Entrant Manufacturing Systems

Queue changes associated with each step of a manufacturing system are modeled by constant vector fields (flow models). A Poincare map reduces these vector fields to a set of piecewise linear maps. It is proved that these maps show only periodic or eventually periodic orbits. An algorithm to determine the period of the orbits is discussed. The dependence of the period on the processing rates is shown for a 2-machine-4-step problem.

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MS41
On the Optimal Scheduling for Warehouses

We apply the ideas of "bucket brigade" production lines to the problem of optimal sequencing of pickers in warehouses. The warehouse model is by necessity stochastic one because the orders of customers are random. nevertheless the knowledge of deterministic dynamics of the corresponding production lines, which appear when the probability to order each item equals one, allowed to essentially increase pick rate.

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MS41
Stability of Queueing and Fluid Reentrant Networks

Evaluating the stability of reentrant queueing networks under various scheduling rules has proved to be a particularly interesting and challenging problem. Significant advances have been made in the last decade by demonstrating a close connection between the stability of the stocahstic model and its continuous determinstic analog, a so-called fluid model. We present recent results demonstrating the subtle connection between the two models and review the techniques used to successfully analyze the stability of fluid networks.

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MS41
A Dynamical Systems Analysis of a Periodic Client-Server Network

We investigate a periodic client server network using a dynamical systems approach. The network consists of n processors, linked to a central server which has a queue of size n-1. We consider the service protocols First In First Out (FIFO) and Last In First Out (LIFO) with 2 and 3 clients with periodic requests to be serviced. For the FIFO case we present formulas to compute efficiency of the system as well as sufficient conditions for no waiting in the queue. For the LIFO case we characterize the behavior of the system.

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MS42
Front Dynamics in a Spatially Discrete System

In many spatially continuous, nonlinear systems the dynamics focusses on coherent structures such as solitary waves or localized fronts that separate homogeneous equilibrium phases. Here we explore the dynamics of coherent structures in spatially discrete systems. Systems of this kind arise in lattice dynamics and in theory of chains of coupled nonlinear oscillators. Notably, we consider the stability of pulses and fronts using a version of the Evans function technique. This method allows us to uncover bifurcations from the continuous spectrum for structures on infinitely long chains and lattices.

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MS42
Existence and Stability of Dark Solitons

The stability of the dark soliton solution to a Ginzburg-Landau perturbation of the defocusing nonlinear Schroedinger equation (NLS) is considered. As an application of dynamical systems techniques, it is shown that the dark soliton can persist as either a regular perturba-

tion or a singular perturbation of that which exists for the NLS. When considering the stability of the perturbed soliton, a major difficulty which must be overcome is the location of eigenvalues which bifurcate out of the continuous spectrum. Since the continuous spectrum for the NLS covers the imaginary axis, such a bifurcation may lead to an unstable wave. When the wave persists as a regular perturbation, it is shown that at most three eigenvalues will bifurcate out of the continuous spectrum. Furthermore, the location of these eigenvalues is tracked precisely, thus leading to a stability criteria. The results are an improvement and refinement of previous studies in which either a variational analysis or an adiabatic analysis were used. Furthermore, the methods used to achieve the results are general and applicable to a wide class of problems.

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MS42

Essential Instability of Pulses and Bifurcation to Modulated Travelling Waves

We study pulses and fronts for reaction-diffusion systems on the real line. Various instability mechanisms which involve the essential spectrum are analyzed: the asymptotic state of the travelling wave solution destabilizes, for example via a Turing instability. We prove existence and stability of bifurcating modulated travelling waves.

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MS43

Geometrical Analysis on the Intracellular Calcium Wave Propagation

We study a two pool model proposed by Goldbeter for intracellular calcium wave propagation by calcium-induced calcium release with attention on the dispersion relations of the periodic traveling wave trains. The temporal behavior of the model can be understood by analogy with FHN dynamics. We consider a more general model with diffusion than the piecewise linear model. By the singular perturbation method we derive a singular equation which behaves like a generic excitable system, fast and slow dynamics are distinct. For a given background IP_3 concentration we show how the dispersion curves begin and which periodic waves are stable.

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MS43

The Spatial Distribution of IP_3 Receptors and the Dynamics of Intracellular Calcium

We analyze the effect of the spatial distribution of IP_3 receptor/Ca2+ channels on the dynamics of intra-cellular calcium. We consider a model of calcium release from the endoplasmic reticulum that describes the emission of calcium from spatially discrete channels and its subsequent continuous diffusion and uptake back into the endoplasmic reticulum. We demonstrate that the discreteness of the release sites can have a dramatic effect on the dynamics of intracellular calcium.

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MS43

Elementary events of Intracellular Calcium Signaling

Intracellular Ca2+ liberation through IP-3- and ryanodine-receptor/channels occurs discontinuously as 'elementary' release events (puffs and sparks), that arise at clusters of channels forming discrete release sites. Individual sites can generate autonomous, transient events involving single or multiple channels, and their activity may be coordinated by Ca2+ diffusion and Ca2+-induced Ca2+ release to propagate global Ca2+ waves. We are studying mechanisms underlying generation of Ca2+ puffs in Xenopus oocytes, and the ways in which Ca2+ diffusion and the spatial arrangement of release sites interact to initiate and propagate waves.

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MS43

Calcium Dynamics in Astrocytes

Intercellular calcium waves in astrocytes have been shown to influence neuronal communication in the central nervous system and may play a role in disorders such as epilepsy. Experiments indicate the calcium dynamics may be mediated by an extracellular messenger via a G-protein linked signal transduction pathway. In this work we derive and analyze a model of calcium dynamics which includes the influence of an extracellular messenger. We examine the influence of the extracellular messenger on both the local calcium dynamics and intercellular calcium waves.

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MS44

Attractors, Chain Transitive sets and Invariant Measures

Given a finite dimensional map of a compact space X to itself, we study the Markov chain approximation of the map based on a partition of X. Assuming the map is continuous, approximations of chain transitive sets and stable attractors are constructed. Using the work of Buescu and Stewart, we will show that the procedure also yields approximations to the SBR measure of a class of transitive Lyapunov stable attractors.

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MS44

Stability of Attractors in Forced Systems

Dynamically invariant submanifolds arise in a variety of contexts, particularly in the area of chaotic synchronisation and its use in communication systems. A common model for such systems is a skew-product of the form $T(x, y) = (f(x), g(x, y))$ in which f is an ergodic map of a compact metric space (X, μ) and $g : X \to R^n$ is a Lipschitz map with negative Lyapunov exponents in the fiber R^n. We study the stability of attractors in such skew-products under deterministic and random perturbation of g.

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MS44

Graphs and the Stability of Stochastically Forced Systems

We describe a framework for the study of the stability of stochastically forced systems. We discuss the significance of invariant graphs in this context and their relationship to invariant measures. We analyse to what extent Liapunov exponents give sufficient conditions for the existence of such graphs and present recent results on their regularity. We explain the relevance of these to dimension increase in recursive filters and to the stability of chaotic synchronization to noise.

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MS45

A Nonlinear Analysis of the Averaged Euler Equations

This talk will survey some of the recent work (with Shkoller, Ratiu, Holm, and Kouranbayeva) on the analysis of the averaged Euler equations. We will begin with a motivational derivation of the equations. Then we show how they may be regarded as geodesics for the H^1 metric on the volume preserving diffeomorphism group, as Arnold did for the Euler equations. Then we will present some of the analytical theorems, as in Ebin and Marsden, including the convergence as viscosity tends to zero in the presense of boundaries. We will also briefly indicate some of the computational aspects of the equations.

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MS45

The SU(n) Approximation to the 2D Averaged Euler Equations

It is now well known that the Poisson bracket on su(n) converges to the Poisson bracket on Lie algebra of all smooth divergence free vectors on the flat two torus. This suggests that SU(n) is a discretization of the area preserving diffeomorphisms of the two torus. We shall discuss numerical simulations in which the SU(n) discretization is used to approximate solutions to the averaged Euler equations. Unlike the usual pseudo-spectral codes that conserve only energu and the first Casimir, this discretization scheme is able to conserve the first n-1 Casimirs.

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MS45

Geometry and curvature of new diffeomorphism groups and the averaged Euler equations

This talk will focus on the geometry of the averaged Euler equations, a system of PDEs whose solutions correspond to the ensemble averaged component of the solutions of the Euler equations. I shall descibe new diffeomorphism groups whose geodesics are the solutions to the averaged Euler equations, computations of the sectional curvuture of these groups, and new sets of boundary conditions that give rise to regular limits of zero viscosity.

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MS45

New Pressure Estimates for the 2D Euler Equation

Using new elliptic regularity results for Jacobian determinants in Hardy spaces, we are able to improve the classical estimates on the pressure function in the two dimensional Euler equations of ideal hydrodynamics.

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MS46

Modelling Multistable Systems

Dynamical processes in nature often possess a multitude of different stable long-term behaviors (attractors) for a given parameter set. Under the influence of noise, the dynamics of such systems consists of regular phases of motion in the neighborhood of attractors and chaotic phases of motion on the complexly interwoven basin boundaries. We show how this hopping process between different attractors can be characterized and discuss the implications on the detection of multistability from observed data.

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MS46

Obstruction To Modelling

I will analyze a new level of mathematical difficulty, brought from the theory of dynamical systems, that can limit our ability to represent nature using deterministic models. Specifically, I will show that certain chaotic systems found in nature cannot be modelled using evolution equations. No model of such a system produces solutions that are realized by nature.

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MS46

Construction of ODE Models from Experimental Data

Physical laboratory experiments can produce high quality chaotic data, so that the data driven construction of equations of motion as ordinary differential equations (ODE) are possible. The talk covers the issues of physical motivation, data requirements, robust estimation of derivatives from data, selection of the model structure, and model verification. Emphasis is laid on non-autonomous systems. Experimental data from a chaotic resonance circuit demonstrate how the change of experimental parameters is reflected in the models.

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MS46

Reconstruction of High-Dimensional Nonlinear Models from Data

We analyze data from high-dimensional dynamical systems, like delayed-feedback and spatially extended systems, using a suitable optimization problem. It is solved numerically in a nonparametric way calculating optimal transformations, a concept of nonlinear regression analysis. For delayed-feedback systems, the delay times and the governing delay-differential equations can be estimated well. We demonstrate the applicability of the method on numerical examples and on experimental data from a ring cavity laser experiment.

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MS47

Complex Spatio–Temporal Dynamics of Neural Networks

We review our recent studies on complex spatio–temporal dynamics of neural network models composed of neurons with chaotic dynamics or coincidence detector neurons, which are derived on the basis of properties of real neurons. We analyse various spatio–temporal dynamics of the models from the viewpoints of not only artificial neurocomputing but also dynamical information processing in the brain. We also consider possible relationship between the model behaviour and physiological data experimentally observed.

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MS47

Detection of n:m Phase Synchronization from Noisy Data

We use the concept of phase synchronization for the analysis of noisy nonstationary bivariate data. Phase synchronization is understood in a statistical sense as an existence of preferred values of the phase difference. Two techniques are proposed for a reliable detection of synchronous epochs. These methods are applied to several neurophysiological data.

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MS47

Synchronization of the Stochastic Dynamics of Paddlefish Electroreceptor Cells

Stochastic synchronization of the noisy internal oscillators of the electroreceptor cells in paddlefish, *Polydon spathula*, with external periodic stimuli is studied in electrophysiological experiments. We find episodes wherein the responses are phase locked to the stimulus separated by periods of phase slippage. The length and times of these occurrences are random numbers. The experimental data are

well described by a noise mediated Hodgkin-Huxley model and by a stochastic circle map.

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MS47

Phase Locked Brain Activity in the Motor System

We developed a new method which makes it possible to detect $n : m$ phase synchronization in noisy nonstationary data [Tass et al., Phys. Rev. Lett. 81 (1998) 3291ff]. We applied our method to multichannel whole-head MEG (magnetoencephalography) data and related signals such as EMG (electromyogram) registered in parallel. Our single run analysis reveals characteristic cerebral synchronization processes that reflect movement coordination and different types of motor control observed under physiological and pathological conditions.

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MS48

Mixing and Diffusion in Aperiodic Flows

The dynamical systems theory of Lagrangian mixing offers a framework in which to study transport in two-dimensional vector fields with regular time-dependence. While the theory has been sucessful in the analysis of periodic or quasi-periodic flows, it fails for flows with general time dependence. In this talk we discuss a geometric theory of mixing for aperiodic fields. The velocity field is assumed to be given numerically or experimentally on a finite grid for a finite time. We describe computer assisted analytic results that idetify finite-time hyperbplic structures in the flow. Applications to ocean dynamics as well as the relevance of finite-time invariant manifolds to the transport of active scalars will be discussed.

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MS48

The Fractal Nature of Vorticity at High Reynolds Number

We consider a smooth Lagrangian chaotic fluid flow at high Reynolds number. It is shown that the smooth flow is unstable to the generation of small scales in which vorticity concentrates on a fractal and has an associated multifractal measure. The possible significance of this result for fully developed turbulence is discussed.

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MS48

Indecomposable Continua in Fluid Flow Past an Array of Cylinders

Fractal structures appear naturally in nonlinear dynamical systems. These structures are invariant sets and are unchanged under the time evoultion of the dynamical system. Many fractals sets in dynamics can be classified topologically as being indecomposable continua. The invariant fractal sets formed in the wake of cylinders of fluid flow past an array of cylinders are shown and some properties of indecomposable continua are used to prove their persistence under the influence of a small amount of noise.

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MS48

Advection in Chaotically Time-Dependent Open Flows

The passive advection of tracer particles is considered in open two-dimensional incompressible flows with chaotic time-dependence. As illustrative examples we investigate flows produced by chaotically moving ideal point-vortices. The advection problem can be seen as a chaotic scattering process in a chaotically driven Hamiltonian system. Studying the motion of tracer ensembles, we present numerical evidence for the existence of a bounded chaotic set containing infinitely many aperiodic trajectories never leaving the mixing region of the flow. These ensembles converge to filamental patterns which, hoowever, do not follow self-similar scaling. Nevertheless, they possess a fractal dimension after averaging over several finite time realizations of the flow. We propose random maps as simple models of the phenomenon.

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MS49

Nonlinear Modal Interactions in a Kicked Flexible

Rod

The Karhunen-Loève (K-L) decomposition is used exerimentally to study modal interactions in a flexible steel rod "kicked" by a spatially triggered electromagnet. Two specific nonlinear modes are shown to interact in the observed dynamics over a wide range of the magnet voltage V. As V increases, a sequence of bifurcations into distinct dynamical regimes is observed: small amplitude limit cycle; quasiperiodic response; chaos; and large amplitude limit cycle. Experimental results are compared to a theoretical model developed with the aid of the K-L data.

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MS49
POD Analysis of the Interaction Dynamics of Coupled Systems in Continuum Mechanics

The POD method is used to analyze the interaction dynamics in coupled mechanical systems consisting of linear continua coupled to nonlinear oscillators. It is found that the linear continuum and nonlinear oscillators interact to produce regular and chaotic motions containing slow and fast time scales observed in the weak coupling limit. This work reveals the role the reduced slow and fast motions of the weakly coupled system play in the creation of the interaction dynamics.

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MS49
Exponential Attractors and Inertial Dynamical Systems in Continuum Mechanics

Exponential Attractors are positively invariant sets, with finite fractal dimension which attract uniformly exponentially all trajectories. We demonstrate their existence in a general context of semiflows in Banach spaces which admit an absorbing ball and are uniformly differentiable therein.The only requirement is for the linearized semiflow to be the sum of a compact plus contraction operator. Applications are made for dispersive viscoelasticity models with Korteweg capillarity . Equivalent inertial dynamical systems are constructed.

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MS49
Nonlinear Normal Modes in a System with Nonholonomic Constraints

Nonlinear normal modes are periodic motions in a multidegree of freedom system defined to be vibrations-in-unison. These have been investigated in holonomic systems since the 1950's. The present work extends these ideas to systems with nonholonomic constraints. We investigate the dynamics of a system involving the planar motion of a rigid body which is restrained by linear springs and which possesses a skate-like nonholonomic constraint known as Caplygin's sleigh. Second order averaging is used. 1:1 internal resonance is investigated.

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MS50
Exchange Lemmas for Singularly Perturbed Problems Certain Turning Points

Singualr perturbation problems with certain type of turning are studied from a geometric point of view. Based on the local property of the turning points initially studied by Pontryagin and the center manifold theory for invariant manifolds developed by S.-N. Chow, W. Liu and Y. Yi, we extend the Exchange Lemma first formulated by Jones and Kopell for normally hyperbolic slow manifolds to the ones with such type of turning points. Applications to various boundary value problems will also be discussed

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MS50
Invariant Manifolds and Foliations for Infinite Dimensional Dynamical Systems

When considering the question of persistence of invariant manifolds for a dynamical system when that system is perturbed, one is naturally led to the concept of normal hyperbolicity. Roughly speaking, this requires that the tangent bundle of the phase space, restricted to the manifold, splits into three subbundles, one of which is the tangent bundle of the manifold and the linearized flow either expands or contracts the other bundles at rates greater than any expansion or contraction in the tangent bundle. In this talk, we shall report our recent works on normally hyperbolic invariant manifolds, especially, overflowing manifolds for infinite dimensional dynamical systems. We do not assume that the manifolds are compact or finite dimensional.The manifolds are not necessarily imbedded manifolds, but immersed manifolds. The existence of invariant foliations will also be given. We should mention that the infinite dimensional dynamical systems generated by, for example, parabolic equations are not reversible and the phase spaces are not locally compact. This characteristic creates difficulties not encountered in the study of finite dimensional dynamical systems and new methods need to be developed to understand the nature of these systems. This is joint work with Peter Bates and Chongchun Zeng.

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MS50
Dynamics of Electronic Oscillators

Early vacuum tube oscillators had their theory in the form of van der Pol equation. Ironically during last 60 years this equation became better known in ODE's than in Electrical Engineering. In the former it contributed to the theory of averaging and integral manifolds and gave rise to Smale's horseshoe, in the latter it became virtually forgotten. This paper aims at bringing the two worlds together. It reviews engineering needs and design methods and compares them with oscillations theory. Common goals as well as different approaches are discussed with the emphasis on possibilities of combining theory and design.

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MS51
Four States of Motion Unique to the Dynamics of Cellular Flames

This talk will present the characteristics of four states of cellular flames with unique dynamics. In hopping states individual cells abruptly change their angular position in a sequential manner. Ordered states exhibit an intrinsic chaotic wiggling in 2-D patterns but not in 1-D lines of cells. In intermittently ordered states patterns of concentric rings of cells appear and disappear at irregular intervals. Ratcheting states correspond to very slow, nonuniform rotations of one or more rings of cells.

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MS51
Interaction of Counterpropagating Hot Spots in Solid Fuel Combustion

We consider combustion waves propagating along a cylindrical solid fuel sample, describing the Self Propagating High Temperature Synthesis process to synthesize advanced materials. There exist spinning modes of propagation, characterized by hot spots (localized high temperature pulses) which rotate around the sample as they propagate, thus following a helical path on the cylinder. We analyze interacting counterpropagating hot spots, thus describing the phenomena of apparent annihilation and creation of hot spots, recently observed in experiments.

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MS51
Nonlinear Dynamics in Frontal Polymerization

Frontal polymerization (FP) is a mode of converting monomer into polymer via a localized reaction zone that propagates. The conditions for existence of free-radical FP are considered. Convective and thermal instabilities pose serious challenges to commercialization, and the results of sounding rocket and parabolic airplane flights will be discussed. Special consideration will be given to spin mode instabilities and the similarities and differences to phenomena observed in Self-Propagating High Temperature Synthesis.

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MS51
Mathematical Modeling of Frontal Polymerization

Frontal polymerization (FP) is a process in which a localized reaction zone propagates into a monomer, converting it into a polymer. The process is currently under investigation as a novel method to produce polymers. Mathematical models of FP involve highly nonlinear interactions between chemical kinetics and heat/mass transfer processes. We develop a mathematical model of FP and determine the structure of the polymerization wave, its propagation velocity and their dependence on the problem parameters.

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MS52
Computation of Lyapunov Exponents via Spatial Integration with Application to Blowout Bifurcations

We describe a new method for approximating the largest Lyapunov exponent which is found as the limit of a sequence of integrals with respect to the invariant measure. The integrals may involve either a matrix norm or a vector norm. This approach requires much less computation than a long term simulation of a dynamical system for the detection of blowout bifurcations in coupled systems. The new method is illustrated for two coupled Duffing oscillators.

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MS52

The Numerical Computation of Rigorous Coverings for Invariant Manifolds

We present robust techniques for the numerical approximation of (multidimensional) invariant manifolds. These methods rely on a multilevel subdivision procedure for box coverings which gives convergence on compact subsets. Additionally, we can construct rigorous coverings using Lipschitz estimates. As an example we present a covering of a two-dimensional unstable manifold of a periodic orbit in the circular restricted three body problem. This result is of potential interest for the design of spacecraft missions.

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MS52

Symbolic Dynamics for Time Series

Using data obtained from a magnetoelastic ribbon experiment we show how a new approach based on topological techniques can be used to obtain a description of the dynamics in terms of subshift dynamics on a finite set of symbols. These topological methods have been developed in a way that allows for the inclusion of experimental error and the existence of bounded noise.

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MS52

Numerical Approximation of Random Attractors

We will present an algorithm (based on the subdivision algorithm of Dellnitz and Hohmann) for the numerical approximation of attractors for random dynamical systems, which serve as a model for dynamics influenced by probabilistic noise. Its application gives surprising new insights into the structure of the attractor of the stochastic Duffing–van der Pol oscillator. The resulting approximations suggest that a stochastic perturbation of a system close to a Hopf bifurcation point can cause chaotic dynamics.

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MS53

Relative Equilibria of Tethered Satellite Systems

We study existence and stability of relative equilibria for a system of two satellites joined by a continuous tether. For circular orbits of the satellites we calculate all possible positions of the tether and their stability by means of the second variation of the amended potential. We focus on very stiff tethers and show that equations for relative equilibria and stability conditions are well approximated by the corresponding equations and conditions for an inextensible tether.

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MS53

Nonlinear Dynamics of Tethered Satellite Systems

The equations of motion of a tethered satellite system are highly nonlinear and the dynamics possesses many interesting features. The paper examines the stationkeeping phase first. It is noted that regions of both regular and chaotic motions exist for planar as well as three dimensional cases. The size of these regions depends on eccentricity and the value of the Hamiltonian. The deployment/retrieval phases are also considered. Amplitudes of limit cycle oscillations during controlled retrieval are determined.

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MS53

Numerical Treatment of the Relative Equilibrium Equations

The stability problem of relative equilibria requires first the calculation of the relative equilibria from a nonlinear boundary value problem. Second one has to check whether the amended potential of the configuration under investi-

gation has a minimum. Both approaches can be performed only numerically for practically relevant examples. Planar equilibria of tethered satellites are calculated by applying homotopy and collocation methods. The minimum property of the amended potential is shown by solving a generalized eigenvalue problem.

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MS53
Modelling and Equations of Motion of Tethered Satellite Systems and Some Simulation Results

The tether is modelled as a viscoelastic string and the satellites as rigid bodies, taking into account the possibility of deployment and retrieval of the tether. The equations of motion, derived from a variational principle for a specially selected set of variables, are a stiff system of nonlinear coupled partial and ordinary differential equations. Their numerical solution is explained and some simulation results of important operational processes, displaying unstable and chaotic dynamics are presented.

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MS54
Underwater Vehicle Dynamics and Stabilization

We present the dynamics of underwater vehicles following work of Leonard and Marsden and others. This problem involves the Euclidean symmetry group and the relevant reduction theory for mechanical systems with this symmetry is reviewed. Finally, work of Bloch, Leonard and Marsden on stabilization of Euler–Poincaré systems that is relevant to this problem will be presented.

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MS54
Validity, Structure and Universality of the Ginzburg-Landau Equations

Bifurcations that take place in spatially-extended systems are believed to be governed by simpler 'universal' PDEs known as Ginzburg-Landau equations. We will describe results on the validity, structure and universality of the Ginzburg-Landau equations. In particular, we show how the underlying Euclidean symmetry explains the universality (and lack thereof) of the Ginzburg-Landau equations.

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MS54
Bifurcations and Dynamics of Spiral Waves

Spiral waves and scroll waves arise in a variety of biological and chemical systems. These systems are often modeled by reaction-diffusion syste on the entire plane or the three-dimensional space. In this talk, recent efforts are described to understand transitions from spiral waves or scroll waves to more complex patterns utilizing only the underlying Euclidean symmetry. Examples include hypermeandering spirals, and scroll waves under periodic forcing.

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MS55
Nonlinear Control Design for Turbocharged Diesel Engines

A Control Lyapunov Function based method for robust nonlinear controller design is applied to a diesel engine equipped with a variable geometry turbocharger (VGT) and an exhaust valve recirculation (EGR) valve. VGT varies the turbine flow area to provide faster torque response. EGR valve allows controlled recirculation of exhaust gas into the intake manifold to reduce NO_x emissions. This control design problem is characterized by significant interactions between the actuators and inherently nonlinear nature of the diesel engine. Performance of the closed loop system is illustrated by simulations and experimental data.

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MS55
Theory and Application of Injection Locking

Injection-locking is a process whereby the frequency of a autonomous system (oscillator) tracks the frequency of a periodic input signal. Although related to more familiar Phase-Locked Loops, the mechanism is a bit different and

offers significant performance and implementation advantages in certain applications. We will present a simple model of injection locking, give an example of numerical simulation of such systems in steady-state, then describe an application of the technique for a commercial integrated circuit.

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MS55

Analyzing Multi-Rate Dynamical Systems Using PDEs

Widely separated time scales arise in many physical systems, especially from electronics, e.g., switched-capacitor filters, mixers, voltage-controlled oscillators (VCOs), etc.. Computation of such systems is often difficult or impossible with available methods, especially when strong nonlinearities are also present. In this talk, we show how it is useful to reformulate such systems in terms of multiple time variables. Doing so transforms differential-algebraic equations (DAEs) to partial differential equations (PDEs) which are much easier to solve than the original DAEs themselves. We show that different multi-time formulations are useful for non-autonomous systems (e.g., mixers) and forced autonomous systems (e.g., VCOs). We also touch on how PDE formulations are useful for macromodelling linear time-varying and nonlinear systems.

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MS55

Input-Output Modeling of Nonlinear Components

I examine the system identification problem for driven nonlinear components especially as it relates to engineering applications. A framework for constructing measurement based black box models of nonlinear components is described based upon extensions of the Taken's embedding theorem. Practical procedure's for constructing models are illustrated to solve fundamental problems such as model and parameter selection. An outstanding problem of a nonlinear model reduction procedure for systems exhibiting large-time scale separations is also described.

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PS

Resonant Pattern Formation in a Reaction-Diffusion PDE System

A numerical study is performed to determine the pattern selection and evolution in a reaction-diffusion PDE system. For the classical Brusselator model the interaction between the reaction and diffusion terms can give birth to the well known rotating spiral waves. When the system is perturbed with a time-periodic forcing term, a spatial reorganization is induced leading to various patterns. Depending on the forcing frequency, locked regimes i.e. standing wave patterns in the forms of labyrinths, fronts, etc are observed similar to the frequency-locked tongues of a driven nonlinear pendulum.

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Elimination of quantization-Induced Limit Cycles in Nonlinear Dynamical Simulations

The use of digital computer simulations to gather probabilistic measures of nonlinear dynamical systems may result in incorrect results due to limit cycles induced by the discrete nature of the computer. This paper proposes the addition of low-level pseudo-random noise to eliminate such limit cycles. The amount of noise added and its effects, both theoretical and observed is examined.

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Information Transmission Through Chaotic Modeling of Language

We propose a new way of communicating, based on the modeling of languages. The message to be sent is the symbolic sequence of a chaotic trajectory. Due to the use of a smart temporal partition, defined based on some statistic properties of the language, few or any interventions are required to target the trajectory in order to produce the aimed message. The message is encoded by transmitting to the receiver those targeting instructions.

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From High Dimensional Chaos to Stable Periodic Orbits: The Structure of Parameter Space

Regions in the parameter space of chaotic systems that correspond to stable behavior are often referred to as windows. In this work, we elucidate the occurance of such regions in higher dimensional chaotic systems. We describe the fundamental structure of these windows, and also indicate under what circumstances one can expect to find them. These results are applicable to systems that exhibit several positive Lyapunov exponents.

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A Study of a Forced Oscillator in an Electric Power System

In power systems a harmful phenomenon known as ferroresonance can occur where over-voltages, over-currents and frequencies different than the frequency of the electric source can be generated. A particular power system has been modelled by seven non-linear, non-autonomous, stiff ordinary differential equations. The model has been investigated using non-linear dynamics techniques and numerical methods. Recent results will be shown.

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PS

Optimal Targeting of Chaos

Standard graph theoretic algorithms are applied to chaotic dynamical systems to identify orbits that are optimal relative to a prespecified cost function. Numerical experiments suggest that periodic saddle orbits of low period are typically less expensive to target (relative to a family of smooth cost functions) than periodic saddle orbits of high period

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On the Inverse Frobenius-Perron Problem (IFPP): Global Stabilization of Arbitrary Invariant Measures

The inverse Frobenius-Perron problem (IFPP) is a global open-loop strategy to control chaos. The goal of our IFPP is to design a dynamical system in Rn which is: 1) nearby the original dynamical system, and 2) has a desired invariant density. We reduce the question of stabilizing an arbitrary invariant measure, to the question of a hyperplane intersecting a unit hyperbox; several controllability theorems follow. We present a generalization of Baker maps with an arbitrary grammar and whose F-P operator are the required stochastic

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Chaotic Choreography

A symbol dynamics induced on a chaotic attractor can be used to generate choreographic variations. Movement sequences produced in this fashion are novel and interesting, but they occasionally violate the kinesiological or stylistic constraints that govern human motion. We solve this problem by building a graph-theoretic model of the joint movement patterns in a corpus of dances and using that model to construct *stylistically consonant* interpolation sequences to "smooth" abrupt transitions in the chaotic variation.

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Dynamics of the Four-Level Laser with Injected Signal

A four level model of the laser with injected signal is considered. It is a more appropriate physical model than the two-level model. Eight equations describe the motion; how-

ever, the system is reduced to 3 equations by using adiabatic elimnation of the polarization and centre manifold techniques. The bifurcation structure is analyzed and a comparison is made with the two level model.

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PS

A Fractal Analysis of Electrotelluric Time Series

The so-called electrotelluric potentials are the spontaneous electric self-potential of the ground. We has obtained electrotelluric potential registers from the state of Guerrero's coast during more than five years. These data sets constitute the so called electrotelluric time series. We show that the measuring of the fractal dimension by means of the Higuchi's method is appropriate; we study the temporal evolution of the fractal dimension and we discuss the feasibility of this method for to identify patterns that would be precursors of seisms with magnitude larger of equal than six.

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A Two-Dimensional Biofilm Model with Fingering Instabilities

Biofilms are collections of microorganisms connected by polymer substances which form in the presence of flowing fluids. Biofilms have many properties of interest such as the spatial heterogeneity of typical biofilms. We present a two-dimensiona biofilm model based on a simple model for viscous, two phase flow. The model will be used to investigate the propagation of the biofilm-fluid interface. Results from numerical simulations of the equations are shown.

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Identification of Decision Systems

This paper considers the problem of developing quantitative models for decision systems based on observations of the input-output behavior of the systems. We begin by showing that a large class of decision systems can be modeled as dynamical systems, and introduce a definition for a (dynamical) decision system which is general enough to allow a wide range of decision phenomena to be modeled and yet retains sufficient structure to permit meaningful system identification problems to be posed and solved. We then present several algorithms for decision system identification and illustrate their use through implementation with decision policies designed using a variety of methods.

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Identification of Hybrid Dynamical Systems I: Theory

This two part paper considers the problem of developing quantitative models for (uncertain) hybrid dynamical systems using measured data. We begin by introducing a definition for parameterized hybrid dynamical systems which is general enough to allow a wide range of systems to be modeled and yet retains sufficient structure to permit meaningful system identification problems to be posed and solved. We then present a new approach to hybrid system identification and illustrate its use through the development of several parameter identification algorithms. In a companion paper we demonstrate the effectiveness of both the hybrid system modeling framework and the identification algorithms through several case studies involving systems

of importance in applications.

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Optimal Chaos Control Through Reinforcement Learning

A chaos control algorithm based on reinforcement learning is described that can be used for the stabilization of unstable periodic orbits as well as for targetting. No analytical description of the map nor knowledge of the location of the periodic orbits to be stabilized is required. Numerical tests for the logistic map, the Henon map and a forced oscillator model for the heartbeat demonstrate good and fast performance of the algorithm also under noisy and nonstationary conditions.

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Chaotic Transitions and Low-Frequency Fluctuations in Semiconductor Lasers with Delayed Optical Feedback

We investigate a single-mode semiconductor laser system pumped near threshold and subject to optical feedback. In particular, we study chaotic transitions leading to the low-frequency fluctuations (LFFs) by numerical integration of Lang-Kobayashi equations. We classify different types of chaotic transitions by computing bifurcation diagrams covering a wide range of feedback levels. Our computations suggest that LFFs can be either sustained or transient, depending on parameters of the system.

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Unstable Periodic Orbits and the Transition to High-Dimensional Chaos

We study the transition to high-dimensional chaos (more than one positive Lyapunov exponent) by analyzing properties of unstable periodic orbits (UPOs) embedded in the chaotic attractor. Heuristic argument and explicit computation of UPOs for several high-dimensional maps suggest that the transition is usually accompanied by a type of nonhyperbolicity common in high-dimensional systems: unstable dimension variability. We argue that due to unstable dimension variability, subsequent Lyapunov exponents typically pass through zero smoothly from the negative side.

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A Variational Principle for the Amplitude of Limit Cycles

The amplitude of limit cycles of Liénard type equations $\ddot{x} + F(\dot{x}) + x = 0$, for $F(\dot{x})$ such that a single limit cycle exists can be obtained from a variational principle. We apply it to the Rayleigh-van der Pol equation to show explicitly how to recover some known results without resorting to perturbation theory.

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Unstable Periodic Orbits and the Natural Measure of Nonattracting Chaotic Saddles

We investigate the characterization of the natural measure of nonattracting chaotic saddles by unstable periodic orbits embedded in the saddle. Results with the Hénon map for which periodic orbits can be enumerated lend credence to the conjecture that the unstable periodic-orbit theory of the natural measure is applicable to chaotic saddles, hyperbolic or nonhyperbolic. As a related problem, we investigate the scaling of the probability of experimentally detecting unstable periodic orbits embedded in chaotic saddle. We find, through heuristic theoritical argument and

sytematic numerical experiments, that the probability typically decreases exponentially as the period increases with an exponent determined by the dynamical invariants of the chaotic saddle.

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Controlling Transient Chaos in Deterministic Flows with Applications to Electrical Power Systems and Ecology

Transient chaos is a common phenomenon in nonlinear dynamics of many physical, biological, and engineering systems. In applications it is often desirable to maintain sustained chaos even in parameter regimes of transient chaos. We address how to sustain transient chaos in deterministic flows. We utilize a simple and practical method, based on extracting the fundamental dynamics from time series, to maintain chaos.The method can result in control of trajectories from almost all initial conditions in the original basin of the chaotic attractor from which transient chaos is created. We apply our method to three problems: (1) voltage collapse in electrical power systems; (2) species preservation in ecology; and (3) elimination of undesirable bursting behavior in a chemical reaction system.

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Dynamical Systems Methods for Geophysical and Environmental Modeling

In this talk, I will present the results on stochastic as well as deterministic dynamical systems methods for prototypical models in geophysical and environmental systems.

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A Novel Measure of Nonstationarity in Dynamical Systems

We use a concept from information theory, namely the *information flow* (IF), to measure qualitative changes in nonstationary dynamical systems. In several model simulations where parameter changes are imposed on the systems, we find that the IF can detect and predict accurately the onset of nonstationarity and/or the changes of dynamical behaviours (e.g. a reduction of dynamical "complexity"). In the context of the detection and prediction of dynamical events (e.g. mechanical failures, unstable laser emissions, neurophysiological diseases such as epileptic seizures or cardiac arrythmia ...), we argue that the IF could serve as a characteristic *precursor* for the actual onset of the events. In the best of all possible worlds, knowledgeable ("therapeutic") dynamical intervention becomes possible.

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The Breakdown of Shadowing in a Typical Physical System

The sinusoidally forced, damped, double pendulum is presented as a simple paradigm system that is unshadowable due to the presence in the attractor of periodic orbits that have different numbers of unstable directions. An argument is provided for the existence of parameter values where shadowing fails. Numerical simulations show attractors containing fixed points with different numbers of unstable directions. Finite-time Lyapunov exponents whose signs fluctuate, the hallmark of unshadowable systems, are also observed.

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Periodic Solutions of Neutral Functional Differential Equations: a Case Study

Bifurcation analysis of periodic solutions of neutral functional differential equations (NFDEs) faces a number of important new difficulties when compared with retarded

FDEs. The Poincaré operator is no longer a compact operator, instead it has both a point and an essential spectrum. We examine a specific example using a high-dimensional approximation combined with a numerical method that exploits the spectral properties to reduce the computational costs. Using these tools we show new dynamical phenomena (sensitivity to infinitesimal parameter changes, bifurcations of the essential spectrum) and raise a number of open theoretical questions.

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A Geometric Method for Calculating Diffusive Traveling Waves in Coupled Systems

A geometric method to approximately find dispersive traveling waves of two coupled reaction diffusion equations is given. Finding these waves involves two distinct processes: finding a state space connection between critical points of the equation's nonlinearity, and finding a physical space traveling wave that takes values on the state space connection as a function of space and time. This paper describes a method that decouples these two processes in certain parameter regimes.

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Defect Dynamics in the Vector Complex Ginzburg-Landau Equation

The vector complex Ginzburg-Landau equation is the amplitude equation for the envelope of nonlinear oscillations of a vector field close to a Hopf bifurcation. This situation occurs, for example, in a large-aperture laser near threshold. Dynamical states in two spatial dimensions are characterized by different kinds of defects with a rich behavior. We describe such states, and analyze some aspects of the defect dynamics, in particular creation, annihilation and unbinding phenomena.

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Extracting Signals from Chaotic Laser Data

Several experimental groups have demonstrated communication with chaotic lasers. Although the focus has not been on message security, it is believed that the dynamics typically lie on attractors of large dimension which may make it impossible to extract the hidden message using nonlinear forecasting techniques. In this paper, we analyze data from numerical simulations inorder to determine what system information is necessary to make unmasking possible. We also comment on results using actual experimental data.

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1:2 Resonance Mediated Transmission Band Gap Opening in a 1-d Nonlinear Discrete Periodic Medium

We consider wave propagation in a nonlinear infinite diatomic chain of particles as a discrete model of propagation in a medium whose properties vary periodically in space. The particles have alternating masses M_1 and M_2 and interact in accordance to general nonlinear force F acting between the nearest neighbors. Using Fourier series methods and tools from bifurcation theory, we show that, for each 1:2 resonant wave-number k, there are two different frequencies $\omega_{1,2}$, such that the system admits nontrivial small-amplitude traveling wave solutions g and h, depending only on the linear combination $z = kn - \omega_{1,2}t$. We determine the nonlinear dispersion relations explicitly.

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Correlation of Inhaled Formaldehyde Flux Predictions with Regional DNA-Protein Crosslink Measurements in Rat Nasal Passages

DNA-protein crosslinks(DPX) are used as a dosimeter for inhaled formaldehyde and are associated in the presence of

tumors in rat nasal passages. Using a physiologically-based pharmaco kinetic model for uptake of formaldehyde and a 3-D computational fluid dynamics model of the rat nasal passages, we correlate mass flux and exposure concentration with DPX in two separate regions of the nose (high tumor and low tumor). We show that the mass flux, rather than the exposure concentration, is the dominant factor for the different lesion formation in these two regions.

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Identification of Hybrid Dynamical Systems II: Case Studies

This two part paper considers the problem of developing quantitative models for (uncertain) hybrid dynamical systems using measured data. In the first part we introduce a useful definition for parameterized hybrid dynamical systems and present a new approach for identifying these systems. In this part of the paper we illustrate the effectiveness of both the hybrid system modeling framework and the approach to system identification through several case studies taken from the field of intelligent control. Included among the example systems we study are a simple constrained robotic system, an automated highway system, and an electric power grid under supervisory control.

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Simulation of Socio - Economic Development in Two Areas Competing for Scarce Resources in Tenerife, Canary Islands

On studying the recent development of tourism in Tenerife we will first have to consider the articulation of the two productive models: 'Market' and 'Tertiary' which coexisted largely in "harmony" until the accommodation supply boom on the southern side of Tenerife. Then it appears a structural Change and, after this explosion in the 80's, the Tertiary sector has almost completely displaced the importance of agricultural production. Therefore its entire socio-economic development may be understood purely as a function of fluctuations in Tourist Demand, and its development in a limited environment involves a struggle for scarce resources in the localities receiving the yearly current of visitors. From this point of view, we have undertaken a simulation of this socio-economic evolution in the Orotava Valley and the area centering on the municipal councils of Arona and Adeje. A system of logistic type differential equations will be found to accurately model the development in demand flows, under the assumption the potential European market is distributed between these two tourist destinations in accordance with the laws of the Struggle for Scarce Resources. Having completed this simulation exercise successfully, it was found that this conceptual context may also be applied to the distribution of migratory flows between these two areas of the island. In this simulation the main problem deal with parameter identification, which will be solved with the aid of a new technique.

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Random and Deterministic Perturbation of a Class of Skew-Product Systems

This poster is about the stability of chaotic synchronized systems under random and deterministic perturbations. More precisely we study the stability properties of skew-product systems $T(x,y) = (f(x), g(x,y))$ in which the contraction rates in g are non-uniform. We study the orbit stability and stability of mixing under deterministic and random perturbations of g. Our results also have applications to the stability of Iterated Function Systems which 'contract on average'.

Keywords: Skew-Products, Chaotic Synchronized Systems, Random Perturbations.

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Lie Transfer Map Propagation of Perturbed Keplerian Systems

Time evolution of a Hamiltonian system may be represented by a emphLie transfer map. This map can be used to propagate a point in phase space from an initial time to some later time. As an example in celestial mechanics, consider an earth-orbiting satellite. Using a simple geopotential (J_2-perturbation only), we can do orbit predictions without numerical integration and without computing a normal form, the two traditional ways of propagating orbits.

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Boundary Effects on Complex Ginzburg-Landau Dynamics

We study the effects of different types of walls at finite distance on spatiotemporally chaotic regimes of the twodimensional complex Ginzburg-Landau equation. Dirichlet walls seem to have the greatest impact on the dynamics. In particular, target states become stabilized by them. Other phenomena, such as synchronization of boundary wave emission, entrainement by corners, and anchoring of defects by shock lines are also reported.

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Mode Interactions of Globally-Coupled Phase Oscillators

The onset of collective behavior in a population of N globally-coupled phase oscillators with randomly distributed frequencies is studied when there are competing synchronizing transitions at distinct mode numbers $n > l \geq 1$. In addition to the distribution of native frequencies, additive white noise is included in the phase equations to produce diffusion in the phases. For large N, the population is described by a kinetic equation and the normal form equations are derived by center manifold reduction. The resonant mode interaction with $n = 2l$ is considered in detail for populations with couplings and frequency distributions that are reflection symmetric so that the model has $O(2)$ symmetry.

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Exponentially Long Equilibration Times in a 1-D Classical Gas

The quantum mechanical 'freezing out' of the vibrational degrees of freedom for a diatomic gas has a classical counterpart. We consider here a simple, general 1-D model of a classical gas, and show that when the vibrational and translational time scales are well separated, the collisional energy exchanges between the translational and the vibrational degrees of freedom are reduced by an exponential factor. We determine the time scale for the evolution towards statistical equilibrium.

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Karhunen-Loeve Decomposition of Peripheral Blood Flow

We first discuss the effect of embedding time (τ) and dimension (d) on the Karhunen-Loeve decomposition of periodic scalar signals. When $\tau \neq k/2f_i$ (f_i are characteristic frequencies of the signal and k is a positive integer), $2n$ modes are obtained for a n-periodic signal. Secondly, we demonstrate that peripheral blood flow signal contains pairs of modes on a minute time scale. We interpret this result as an evidence that the flow of blood through the cardiovascular system is oscillatory.

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Oscillatory Neurocomputers With Dynamic Connectivity

Our study of thalamo-cortical systems suggests a new architecture for a neurocomputer that consists of high-frequency oscillators. We use Kuramoto's model to illustrate the idea and to prove that such a neurocomputer has oscillatory associative properties. The advantage of such a neurocomputer is that it can be built using VCOs, MEMS, optical switches, Josephson junctions, macromolecules, or oscillators of any other kind.

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Phase Equations for Relaxation Oscillators

We prove that dynamics of arbitrary weakly connected relaxation oscillators can be described by strongly connected phase equations. The phase model has discontinuity at the point corresponding to the in-phase synchronization. We show that many facts of the Fast Threshold Modulation theory developed by Kopell and Somers, such as super-convergence to the synchronized solution, its superstability, etc., can easily follow from the form of the phase model.

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A Generalized Single Wave Model for Unstable Electrostatic Waves

The nonlinear evolution of a unstable electrostatic wave is considered for a multiple-species Vlasov plasma. From the singularity structure of the associated amplitude equation, the asymptotic features of the electric field and distribution functions are studied in the weak growth rate limit. The asymptotic electric field is monochromatic at the wavelength of the linear mode with a nonlinear time-dependence. The structure of the distributions outside the resonant region is given by the linear eigenfunction but in the resonant region the distribution is nonlinear. This generally derived picture corresponds to the single wave model originally proposed by O'Neil, Winfrey and Malmberg for the special case of a cold-beam instability in a plasma of fixed ions. The "single wave" reduction of a multi-species Vlasov plasma supporting a weakly unstable electrostatic mode is implemented. The reduced model is a Hamiltonian system comprised of a nonlinear Vlasov equation describing the interaction of the resonant particles and the monochromatic electric field, and a reformulated Poisson's equation for the time-evolution of the electric field amplitude. We discretize the model and follow the evolution of an unstable wave numerically; special attention is paid to the scaling of wave amplitude with the linear growth rate.

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Nonlinear Polarization Dynamics in Mode-Locked Optical Fiber Lasers

Lab experiments demonstrate that the addition of a passive polarizer in an optical fiber laser cavity can result in the generation of stable optical pulses. Propagation is modelled by coupled nonlinear Schrödinger equations, where the polarizer is treated as a periodic perturbation. Exploiting the variational nature of the equations, the dynamics of pulse solutions can be reduced to an ODE system for which we investigate existence of attracting states, bifurcation structures and stability.

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Thin Liquid Films: Flows on an Imperfect Surface

We use a recently developed numerical scheme in order to compute the flow of a thin film down an inclined surface, within the framework of lubrication approximation. It is found that small perturbations, which could be due to surface roughness, considerably influence the stability of the flow. Analysis of the importance of the involved lengthscales on the stability of the 1D film, as well as the preliminary results for full 2D problem are given.

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The Myltisymplectic Geometry and Variational Integrators for the Camassa-Holm Equation

We show that for a partial differential equation with a second-order Lagrangian that the unique Cartan form naturally arises in the boundary term of the first variational principle. We prove the covariant Noether principle and the multisymplectic form formula. In the application to the the Camassa-Holm equation, we derive a numerical integrator that manifestly conserves the discrete multisymplectic form, as well as, the discrete momentum mappings corresponding to symmetries of the equation.

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Pulse Dynamics in Isotropic and Anisotropic Reaction-Diffusion Systems

We study the dynamics of concentration pulses in a system of reaction-diffusion equations modeling catalytic CO oxidation on Pt(110). Stable pulses have been observed experimentally in this system through the construction of quasi one dimensional domains using microlithography. They have also been found computationally, and, as the model parameters vary, they undergo different types of instabilities (from modulated traveling waves to "backfiring" and spatiotemporal chaos). We perform a systematic study of the instabilities of these pulses in 1-D with a view towards determining the regions of existence of stable pulses and understanding the nature of the instabilities. We take advantage of software and mathematical results on global bifurcations to compute pulses as homoclinic orbits of a (three-dimensional) set of ODEs arising from the PDE in a traveling frame. Approximating the pulses by wavetrains of large wavelength, and discretizing the PDE in space we numerically approximate the spectrum of the pulses and compute their full PDE stability. We then proceed to examine the effects of anisotropy and surface heterogeneities on pulse dynamics. Comparisons with 2-D simulations as well as experimentally observed phenomena (from the work of Drs. Hartmann and Imbihl in Hannover) are also presented.

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PS

A Mathematical Model of True Polar Wander

Inertial Interchange True Polar Wander has been suggested as a possible mechanism for rapid continental drift during the early Cambrian era. We have constructed a pedagogical model that captures the essential characteristics of the interchange event by averaging over daily rotations, incorporating a time-dependent moment of inertia tensor coupled to the rotational dynamics, and by including double bracket dissipation.

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PS

Nonlinear Behavior of the Inner Ear

We first decompose the auditory potentials of Mongolian gerbils into the cochlear microphonic (CM) and a compound action potential (N1). We then examine the instantaneous frequency $\nu(t)$ of the CM. The function ν is found to depend on both sound pressure level and frequency. It is substantially affected when the cochlea is damaged by exposure to noise. We give a physical interpretation of the instantantaneous frequency and discuss the possibility of modelling the CM with (possibly coupled) nonlinear oscillators.

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Solitary-Wave Solutions of a Nonlinearly Dispersive Hamiltonian System

The recent study of nonlinearly dispersive evolution equations from physical problems has demonstrated a variety of weak, non-analytic solitary wave solutions as limits of analytic solitary waves, similar to the case of the wave of extreme height in the full water wave problem. Investigating these equations has lead to the understanding of mathematical modeling. I will address these issues by comparing solitary wave solutions of a Hamiltonian system with those of the KdV equation.

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Stochastically Forced Navier–Stokes Equation

We will discuss the long term dynamics of the stochastically forced Navier-Stokes equations. We will present results on the regularity of solutions and the structure of the random attractor under various assumptions. In particular, we will discuss settings under which the attractor has a simple structure and in which the system is ergodic. We will also make rigorous the idea that the system can be viewed as evolving on a finite dimensional phase space at the expense of giving the dynamics an infinite memory.

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Color Map of Lyapunov Exponents of Invariant Sets

The largest Lyapunov exponent of the Lorenz system is used as a measure of chaotic behavior to construct parameter space color maps. In fact, the color map associates points in parameter space to Lyapunov exponent values of the invariant set. An obvious practical application is the use of the color map to alter and manipulate the dynamical state of the invariant set by following an approximately chosen path in parameter space.

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Dynamical Systems as Kolmogorov Data Compressors

The Kolmogorov complexity of a sequence is the length of the shortest program on a Turing-complete machine that produces that sequence. A related concept is compleixty/distortion theory, in which a sequence is to be approximated as closely as possible by a program. In general finding the shortest program to represent real data is impractical. However, by restricting attention to particular simple dynamical systems, "programs" with complexity/distortion approaching the Shannon rate/distortion bound can be found using feasible algorithms.

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Multiple Scales Averaging of Parametric Gain Equations with Periodic Domain Poling

We perform a multiple scales averaging analysis of the parametric gain equations with a rapidly periodically poled nonlinear coefficient. This poling is shown to produce on average an effective cubic nonlinearity which slightly detunes the standard resonance criterion used in quasi-phase-matching theory. The use of asymmetric poling schemes to allow electrooptic tuning of quasi-phase-matched devices is also analysed. Numerical integration of the original equations shows good agreement with the averaged equations.

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Control and Synchronization of Spatially Extended Systems

We investigate the problem of controlling and synchronizing spatially extended systems. For this purpose a new coupling scheme is introduced, that allows to control and synchronize the dynamics with only a few driving signals from local regions. As an application we estimate model parameters of partial differential equations from time series.

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Prediction of Spatio-Temporal Time Series Based on Reconstructed Local States

The starting point for most analysis methods used in Nonlinear Time Series Analysis are measurements of a single observable of the system of interest. Many interesting dynamical systems, however, are spatially extended and thus any description using only a few local or global observables may be incomplete. Therefore, we presented an approach for analyzing and predicting spatio-temporal time series using reconstructed local states. As numerical examples the evolution of different hyperchaotic spatially extended systems is predicted from previously sampled data that are generated by a Kuramoto-Sivashinsky equation, a coupled map lattice and coupled nonlinear oscillators.

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The Hopf Fibration and its Applications

Among the most important topological constructions are Hopf fibrations. That they both play an important role in topology itself and have numerous physical applications lends credence to this statement. In this talk, I will discuss some of these applications as motivation for mathematicians to learn about the physical significance of the Hopf fibration in greater detail than that presented here. I will focus my attention primarily on rigid body rotation and the Hopf fibration $h : S^3 \longrightarrow S^2$.

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Complex Dynamics in the 1:3 Steady Mode Interaction

The dominant spatial resonance in Rayleigh-Bénard convection with periodic boundary conditions and midplane reflection symmetry is the 1:3 resonance. For low Prandtl numbers the normal form describing this steady-state interaction exhibits complex dynamics, including standing, traveling, and modulated traveling waves, as well as a heteroclinic connection between circles of standing waves and mixed states leading to chaotic dynamics of Shil'nikov type.

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PS

Unstable Periodic Orbits of Area Preserving Mappings

Unstable periodic orbits (UPO) play a fundamental rôle in the geometrical and dynamical properties of chaotic systems. Their locations are of prime importance for example in the control of chaos, and the calculation of invariant measures and, through the cycle expansion theory, the UPOs provide an essential link between the classical and the quantal world. In the mixed phase-space of non-integrable conservative systems, the localization of UPOs is often a non trivial matter. We extend to the cases of area preserving mappings the results of an algorithm recently proposed by Schmelcher and Diakonos (1997). We treat 4 typical cases: i. the standard map, ii. the general Cremona (quadratic) map, and the Poincaré maps of two Hamiltonian flows (2 degrees of freedom) , namely iii. the Hénon-Heiles Hamiltonian, and iv. the Diamagnetic Kepler Hamiltonian. Our calculations confirm the versatility of the method and establishes its usefulness for area preserving systems.

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1-D Biofilm Models

A single species biofilm model is presented and the existence of steady state solutions is proved. This simple model, which does not include detachment, suggests that a steady state solution is possisble if the inactivation rate is zero. It is also shown that a steady state solution corresponding to the absence of active biomass is linearly unstable provided the bulk substrate satisfies an inequality involving the observed decay rate. Other biofilm models will be presented and the behavior of possible steady state solutions of the models will be discussed.

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Dispersion Relation and Oscillons in a Continuum Model for Vibrated Granular Media

A simple continuum model for thin layers of vertically vibrated granular media is discussed. The dynamical variables are the layer height and its vertically averaged horizontal velocity. In contrast to the usual Faraday waves the surface waves are excited non-resonantly. Within this framework the dispersion relation and the neutral curve for the onset of waves are closely connected and in quite good agreement with experiments. In the nonlinear regime one-dimensional oscillons are obtained.

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Filling the Rotation Interval at Discontinuous Bifurcations: A Continued Fraction

While studying the definite structured order by which periodic orbits occur in outer tangency bifurcation (see Ref. [1]), we also do a detailed study of the different rotation numbers involved. We find and derive a general continued fraction that describes not only our results but previous ones as well. We explain how this new continued fraction can be implemented to describe different discontinuous changes. [1] C. Robert, *et al.*, Phys. Rev. Lett. **80**, 4867 (1998).

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Critical Exponents for Higher Dimensional Crises

As a system parameter is varied it is common for a chaotic attractor to be destroyed and be replaced by a chaotic transient (a crisis). The average duration of chaotic transients near crisis typically has a power law scaling. Little is known about critical exponents for these scalings in systems that have more than one positive Lyapunov exponent. We generalize previous theory to higher dimensional situations and test our formula using numerical experiments.

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Possible Existence of Stochastic Resonances in Electrotelluric Time Series

The aim of several studies focused on the earth crust, as a complex system, has been to find signals called "precursors"of earthquaques. A common method in this area is the electrotelluric time series analysis. This work presents some results of electrotelluric time series with data sampled at Acapulco station (Mxico) during 1995. This station is near the middle American trench. Our approach analyzes some non-linear properties using spectral methods. We detected frequencies of periodic signals whose behavior, as function of the average intensity of potential fluctuations, shows characteristics of stochastic resonances. This behaviour was observed some days before a M=7.4 earthquaque.

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PS

Big Islands in Dispersing Billiard-Like Potentials

We derive a rigorous estimate of the size of islands (in both phase space and parameter space) appearing in smooth Hamiltonian approximations of two-dimensional scattering billiards. Thus, in this approximation, scattering molecules, having a smooth potential, give rise to nonergodic motion. The derivation includes the construction of a local return map near singular periodic orbits for an arbitrary scattering billiard and for the general smooth billiard potentials, leading to *universality* classes for the local behavior.

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PS

Libration Point Invariant Manifolds and Solar System Dynamics

We present a simple model of the solar system using a series of planar circular restricted three-body systems. Numerical computations of libration point invariant manifold structures provide a starting point for understanding some dynamical processes within the solar system. As templates underlying the orbital dynamics, the invariant manifolds provide a simple explanation for some interesting phenomena; for example, comet resonance transitions, transport between the Kuiper belt and the asteroid belt, and zodiacal dust cloud structure.

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PS

Markovian Analogue to Phase Transitions in Coupled Chaotic Map Lattices

As a way of understand the processes that rule phase transitions (PTs) in diffusively coupled map lattices, we study the presence of PTs in coupled Markovian systems, and show that these PTs are similar to that found for chaotic maps by Miller and Huse. We present the phase diagrams of three dynamical systems, one chaotic and two Markovian, for square and triangle 2D lattices.

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Transition to High-dimensional Chaos in Coupled Oscillators

Systems of coupled nonlinear oscillators often exhibit high-dimensional chaos, i.e., chaos with more than one positive Lyapunov exponent. We investigate how high-dimensional chaos arises in such systems. We find that as a system parameter changes, non-trivial Lyapunov exponents, except for the first one, pass through zero smoothly from the negative side. The relationship between these transitions and the local stability of the synchronization manifold is elucidated.

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Modeling and Controlling Molecular Dynamics

We present a model of laser control of molecular dynamics based on mixed-state quantum mechanics and discuss kinematical restrictions on the expectation values of quantum-mechanical observables and their implications. Illustrative computations for diatomic molecules show that it is possible to attain over 99% of the kinematical maximum of an observable, e.g. the energy of a molecular bond, energy level populations, etc. , by driving the system with an optimal control. Algorithms for finding such controls numerically will be outlined.

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PS
Models for Insect Locomotion I: Dynamics and Stability in the Horizontal Plane

We study the dynamics and stability of legged locomotion in the horizontal plane.nbsp; Motivated by experimental studies, we develop two and three-degree-of-freedom rigid body models with both rigid "peg-legs" and pairs of elastic legs in intermittent contact with the ground.nbsp; We consider prescribed leg displacements and conservative elastic leg models.nbsp; The resulting piecewise-holonomic mechanical systems exhibit periodic gaits whose neutral and asymptotic stability characteristics are largely determined by geometrical criteria.

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PS
Matched Asymptotic Expansions and Smolder Combustion

Smoldering combustion waves describe a solid/gas reaction moving through a porous medium. When the method of matched asymptotic expansions is used on the nonlinear PDEs which model the system, a closure problem arises. Solutions at the leading order depend on solutions at all other orders. One possible new approach to alleviate this problem is presented and applied to a model of smoldering combustion with the goal of describing the transition from smoldering to flaming.

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Extraction of Teleseismic Signal Waveforms from Background Noise using Nonlinear Dynamic Forecasting

This paper considers the use of nonlinear dynamic forecasting to detect and extract hidden teleseismic events representing distant nuclear test explosions from background seismic noise in a real data set collected by the Air Force Technical Application Center (AFTAC). The focus will be on using multistep forecasting methods to extract a faithful representation of the hidden teleseismic signal waveform. Effectiveness will be discussed relative to the signal-to-noise ratio of the hidden signal.

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PS
Cumulative Wavelength as a Source of Dynamical Information of the Molecular Gas Spectra

The Problem of radiative transfer in the multicomponent gas mixtures with non-gray particles and boundaries is solved with a help of the Spectral Line-Based Weighted-Sum-of-Gray-Gases Model. The spectral parameters in this model were calculated using the new distribution function - cumulative wavelength, which allows efficient integration of the radiative transfer equation. Validation of the method is performed for mixtures of combustion gases with soot particles.

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PS
Average Expansion Rates and Dimension of

Strange Nonchaotic Attractors

We calculate the capacity dimension of strange nonchaotic attractors (SNAs) using a new method based on estimations of average expansion rates of the underlying dynamics. The example system used is a quasiperiodically forced circle map. With strong enough forcing, the dynamics of the system changes from two-frequency quasiperiodicity to a SNA. While the Lyapunov dimension is known to be one for this SNA, the capacity dimension is observed to change discontinuously from zero to a value close to two across the transition point.

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The Destruction of Horseshoes in 2D and 4D Symplectic Maps

We study the destruction of the horseshoes in symplectic maps using continuation from an anti-integrable limit. The anti-integrable theory provides a powerful dimension independent technique for obtaining analytical bounds on parameter ranges where horseshoes exists. Using a numerical continuation method, we follow orbits from their anti-integrable limit to the bifurcation where they are created. In particular, we study the family of homoclinic orbits whose birth is responsible for the destruction of the horseshoe.

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PS

Fractal Dimension in Higher-Dimensional Chaotic Scattering Systems

We have tested a conjecture which gives formulas relating the dimension of invariant manifolds in "typical" chaotic scattering systems to average dynamical quantities. A three degree of freedom system will be described and formulas for the dimension of the stable manifold of the chaotic saddle presented. These formulas, along with numerical simulations, confirm the conjecture. The notion of "typical" is explained, and new insight is gained into the nature of atypicality.

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Microextensive Chaos of a Spatially Extended System

By numerically simulating the one-dimensional Kuramoto-Sivashinsky equation with rigid boundary conditions over the range $80 \leq L \leq 90$, we show that the Lyapunov fractal dimension D shows "microextensive" scaling in that D increases linearly with system size L even for increments δL that are small compared to the characteristic cell size of about 9. This suggests that the extensive increase in dimension with system size is not related to the appearance of new linearly unstable modes.

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PS

Symbolic Analysis of Non-Stationary Time Series

Symbolic time series methods (where one converts an analog signal into a disrete one via severe coarse graining) have been successful in applications to many traditional problems in stationary time series analysis. For example: the detection of patterns, estimation of corrrelation timescales, discrimination, and parameter estimation. In this poster we will discuss the extension of these methods to weakly non-stationary systems with particular emphasis on the early detection of bifurcation precursors.

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Particle Dynamics and Mixing in the Frequency Driven Kelvin Cat Eyes Flow

Particle dynamics, mixing and transport in multi-frequency driven Kelvin cat eyes flow is studied. The Topological Approximation Method (TAM) is implemented to quantify mixing and transport. This investigation is re-

lated to a more general study of acoustically driven spray combustors. When multi-frequency forcing is applied to the fuel injector nozzles of a combustor, considerable improvements in mixing of the fuel droplets is expected thereby influencing the efficiency of the combustor.

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PS

Binary Fluid Convection as a 2x2 Matrix Problem

Eigenvalues of 2x2 matrices undergo either avoided crossing or complex coalescence, depending on sign of coupling (product of off-diagonal terms). Convection driven by competing thermal and concentration gradients can be viewed as the superposition of pure thermal and solutal problems, with coupling proportional to separation parameter. Surprisingly, both nonlinear convection amplitude and eigenvalues governing stability can be interpreted this way. Hopf and saddle-node bifurcations both result from complex coalescence due to negative coupling.

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Synchronization and Communication using Chaotic Frequency Modulation

In this paper we propose a chaotic frequency modulation (CFM) technique for spread spectrum communications. Existence and stability of the synchronous mode is demonstrated analytically and numerically. Unlike synchronization of two conventional chaotic oscillators via FM channel, the proposed method provides selectivity with respect to interference *within* the frequency range of chaotic frequency oscillations. This method can be a viable alternative to the recently proposed "interpolated" frequency hopping for spread spectrum communications.

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Symmetry-Breaking of Eddies in Expanding Flows

Incompressible flows at a moderate Reynolds number in a symmetrically expanding two-dimensional channel exhibit a pitch-fork bifurcation, as Reynolds number increases, from a symmetric pattern of separated eddies into asymmetric patterns. A simple averaged equation that captures the transition is constructed, extending the boundry layer equations which develops singularities at separation points. The new averaged equation will be helpful in further studies of separated flows and free-surface flows that exhibit transitions in their flow patterns.

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Bifurcation and Dynamics of a Simple Power System Model

Large scale power networks can be modelled effectively using either an ODE or DAE representation. The dynamics of a small model power system are investigated using numerical techniques. Interesting new features of the bifurcation structure of this model are presented, including a Bogdanov-Takens point, and the implications for real networks are discussed.

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PS

Horseshoes in Two-Degree-of-Freedom Hamiltonian Systems with Saddle-Centers

We consider a class of two-degree-of-freedom Hamiltonian systems which have saddle-centers with homoclinic orbits and do not take the form of small perturbations of integrable systems. Using a Melnikov-type global perturbation technique, we present a criterion for the existence of horseshoes in their dynamics on energy level sets near ones of the saddle-centers. It is especially remarkable that the criterion is very similar to that for the existence of transverse homoclinic orbits to resonant periodic orbits in dissipative, time-periodic perturbations of the Hamiltonian systems. We also give an example for the undamped, coupled Duffing oscillators to demonstrate the theory.

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PS

Diffusion in Action Space for Weakly Nonintegrable Hamiltonian Systems

Starting from the Liouville equation for the single-particle phase-space distribution of a weakly nonintegrable Hamiltonian system, the coarse-grained distribution function of action variables is studied by means of projection operator. It is shown that this coarse-grained distribution function is governed by a kinetic equation similar to the Fokker-Planck equation but with memory integral. For localized

nonlinear perturbations, this kinetic equation can be reduced to a functional map. Further approximation leads to a momemt map which can be iterated numerically for studying action dynamics.

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Distributions of Rotation Numbers

The main object of study for chaotic circle maps is the interval of rotations numbers. This interval carries a lot of information about the existence of orbits. We investigate the rotation interval from the perspective of the likelihood of orbits with given rotation numbers and define the "distribution of rotation numbers". Even though rotations numbers of individual orbits cannot be calculated, we show that this distribution can be approximated numerically and compute it for examples.

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Forecasting High Waters at Venice Lagoon using Chaos Theory Techniques

Time series analysis using non-linear dynamics systems theory has been applied to water level data recorded every hour at "Punta della Salute" Venice Lagoon during 1980-1994. The results based on the reconstruction of the state space using the embedding theorem are presented. Moreover, a local look-up model based on the dynamic dimension, has been used to estimate the evolution of the system as well as the predictability limits.

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Wavelet Approach to Hamiltonian Problems

We present applications of the methods from wavelet analysis to a number of Hamiltonian problems and their perturbations, KAM problems, quantization problems. We consider dynamical problems in invariant variational approach via coadjoint orbit picture, semiproducts and metaplectic structure. We construct symplectic, Poisson and quasicomplex structures using generalized wavelets and nonstandard representations for operators in wavelet bases (coherent, well localized) in functional spaces or scale of spaces. We consider applications of our approach to the theory of homoclinic chaos, renormalization group calculations and quasiclassics.

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PS

Subsystem Recurrences in High-dimensional Chaotic Systems

By estimating low-period UPOs using near recurrences in short time-series, we show that the number N_R of recurrences scales as $\epsilon^{D_{NR}}$ with recurrence radius ϵ, where D_{NR} is a recurrence dimension. Using the Kuramoto-Sivashinsky equation, we demonstrate that the probability of finding recurrences in nearby subsystems is not independent. This suggests that extensive chaotic systems should not be interpreted as being made up of weakly coupled independent subsystems.

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Fifth SIAM Conference on

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Eleventh ACM–SIAM Symposium on DISCRETE ALGORITHMS (SODA 2000)

January 9–11, 2000

Holiday Inn Golden Gateway Hotel • San Francisco, California

Sponsored by ACM-SIGACT and SIAM/DM

Organizer: David B. Shmoys, *Cornell University*

Abstract deadline: July 13, 1999

Eighth International Conference on NUMERICAL COMBUSTION

March 5–8, 2000

Amelia Island Plantation • Amelia Island, Florida

Conducted by SIAM in cooperation with INRIA

Organizers: John D. Buckmaster and D. Scott Stewart, *University of Illinois, Urbana-Champaign*; Mitchell Smooke, *Yale University*

Abstract deadline: September 15, 1999

Third SIAM Conference on MATHEMATICAL ASPECTS of MATERIALS SCIENCE

May 21–24, 2000

Crown Plaza Hotel • Philadelphia, Pennsylvania

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Abstract deadline: December 15, 1999

Tenth SIAM Conference on DISCRETE MATHEMATICS

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Sponsored by SIAM Activity Group on Discrete Mathematics

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Tsarin, Yury A., ... CP36, Wed. PM
Tsega, Yamlak, ... PS, Wed. PM
Tsujikawa, Tohru, ... CP28, Tues. PM
Tuckerman, Laurette, ... CP2, Sun. PM
Tuckerman, Laurette, ... PS, Wed. PM
Tuffillaro, Nicholas B., ... MS55, Thur. AM

U

None

V

Valente, Andre Xavier C. N., ... CP9, Sun. PM
van der Heijden, G. H. M., ... CP39, Wed. PM
Van Vleck, Erik S., ... CP37, Wed PM
Varona, Pablo, ... CP12, Mon. PM
Veen, Lennaert van, ... CP10, Mon. PM
Venkataramani, Shankar C., ... MS28, Tues. AM
Verhulst, Ferdinand, ... CP10, Mon. PM
Vishnevskii, Mikhail, ... CP34, Tues. PM
Volkovskii, A. R., ... PS, Wed. PM
Vollmer, Jurgen, ... MS25, Mon. PM
Volpert, V.A., ... MS51, Thur. AM
Voss, H., ... MS46, Thur. AM

W

Walkden, Charles, ... MS6, Sun. AM
Walkenstein, Jonathan A., ... CP40, Wed. PM
Walker, David M., ... MS5, Sun. AM
Walsh, James A., ... MS41, Wed AM
Wang, Don, ... MS6, Sun. AM
Wang, Qi, ... CP44, Wed. PM
Wang, Shouhong, ... CP34, Tues. PM
Wang, Xiaoming, ... MS28, Tues AM
Warnock, Robert L., ... CP40, Wed. PM
Watanabe, Shinya, ... PS, Wed. PM
Watts, Duncan J., ... MS22, Mon. PM
Wei, Juncheng, ... MS30, Tues. AM
Wiesel, William E., ... CP14, Mon. PM
Wiggins, Chris H., ... CP26, Tues. PM
Wilber, J. Patrick, ... CP24, Tues. PM
Wilkinson, Amie, ... MS6, Sun. AM
Williams, Chris, ... MS31, Tues. AM
Wilson, Jon P., ... PS, Wed. PM
Witt, Annette, ... MS3, Sun. AM
Wittenberg, Ralf W., ... MS14, Mon. AM
Wojtkowski, Maciej, ... MS25, Mon. PM
Wriggers, Peter, ... MS16, Mon. AM

X

Xia, Zhihong Jeff, ... IP10, Thurs PM

Y

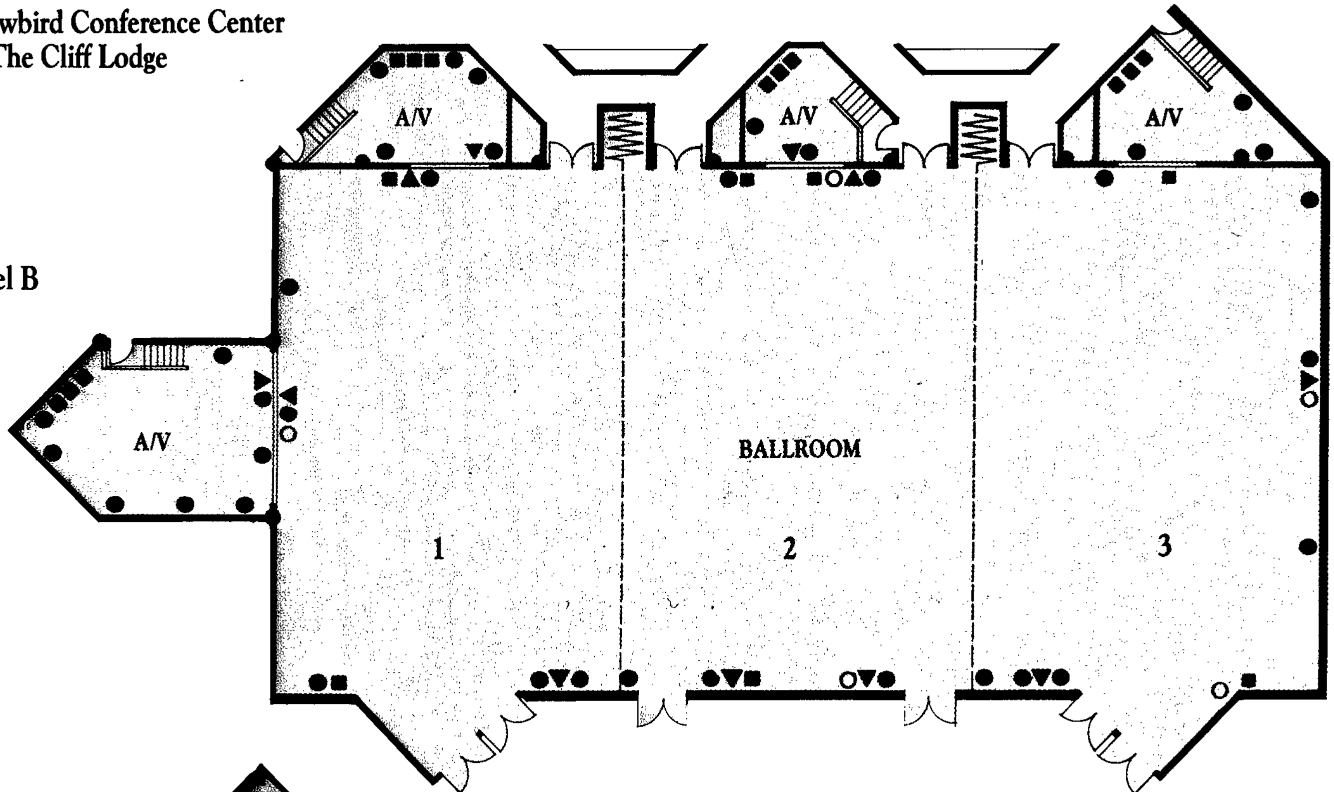
Yagasaki, Kazuyuki, ... CP7, Sun. PM
Yagasaki, Kazuyuki, ... PS, Wed. PM
Yang, Jianke, ... CP21, Tues. PM
Yang, Tian-Shiang, ... CP31, Tues. PM
Yao, Demin, ... PS, Wed PM
Yeung, M. K. Stephen, ... CP27, Tues. PM
Yew, Alice C., ... CP21, Tues. PM
Young, Lai-Sang, ... IP2, Sun PM
Yorke, James A., ... MS38, Wed. AM
Yorke, James A., ... MS26, Tues AM
Yoshikawa, Toshio, ... CP2, Sun. PM
Young, Todd Ray, ... PS, Wed. PM
Yuan, Guo-Cheng, ... CP33, Tues. PM

Z

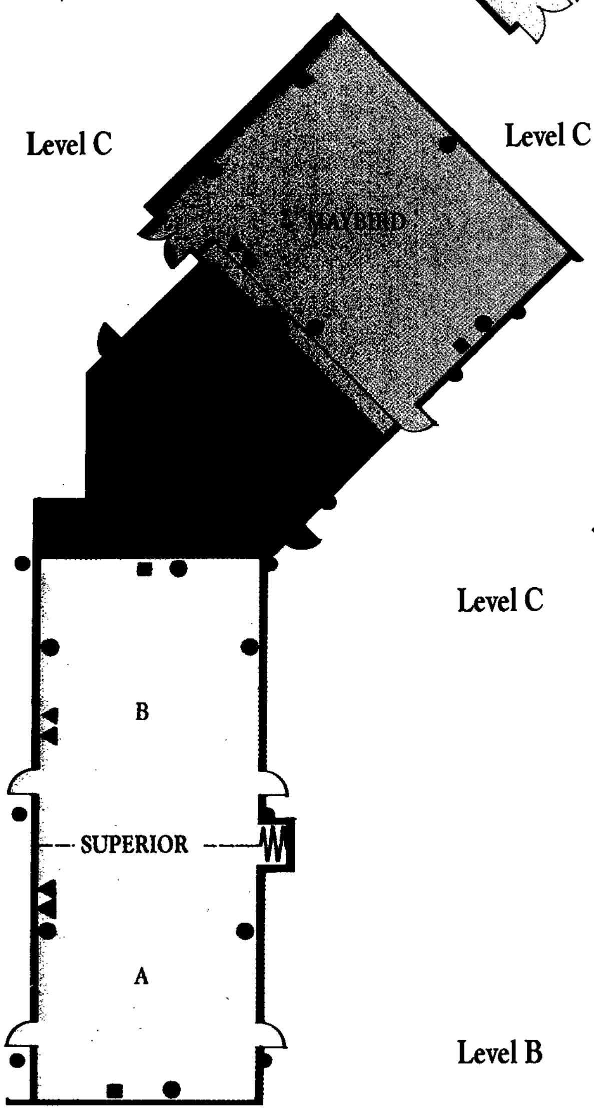
Zaks, Michael A., ... MS39, Wed. AM
Zaldivar, Jose M., ... CP26, Tues. PM
Zaldivar, Jose M., ... CP35, Wed. PM
Zaldivar, Jose M., ... PS, Wed. PM
Zapert, Radoslaw, ... CP35, Wed. PM
Zegeling, P. A., ... CP32, Tues. PM
Zeitlin, Michael, ... PS, Wed. PM
Zeitlin, Michael, ... CP40, Wed. PM
Zeng, Chongchun, ... MS30, Tues. AM
Zgliczynski, Piotr, ... CP22, Tues. PM
Zharnitsky, Vadim, ... MS18, Mon. AM
Zharnitsky, Vadim, ... CP31, Tues. PM
Zhou, Hong, ... CP44, Wed. PM
Zoldi, Scott M., ... PS, Wed. PM
Zoldi, Scott M., ... MS14, Mon. AM
Zou, Xingfu, ... MS1, Sun. AM

Snowbird Conference Center
At The Cliff Lodge

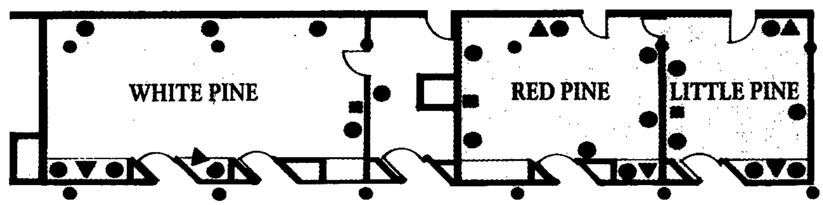
Level B



Level C



Level C



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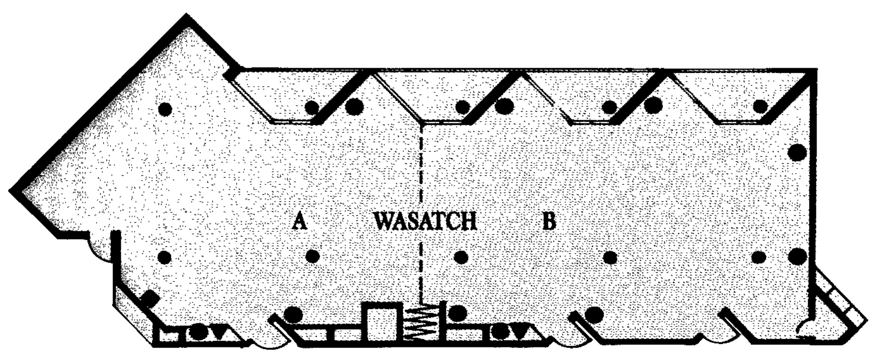

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